CHAPTER 3
Hydrogeologic System

GROUNDWATER FLOW

Hydrostratigraphy and Hydrogeology

The main groundwater resources in the model area are the Surficial Aquifer System, and the Floridan Aquifer System. These aquifer systems are separated by the Intermediate Confining Unit. The Floridan Aquifer System is divided into the upper, middle and lower sections separated by Middle Semi-Confining Units.

The general geology and hydrogeology for south Florida is given in the **Figure 8**. The abbreviations used in for aquifer systems, aquifers, permeable zones and confining units as defined in this study are the same as those shown in the second column of **Table 1** for the regional ASR study. The cross-sections and the hydrostratigraphic layers in the following section are all subsets of the data from Reese and Richardson 2004. The surfaces were developed in VIEWLOG SYSTEMS (VIEWLOG), an application of Earth*fx* Inc. VIEWLOG links to the SFWMD environmental database, DBHYDRO via Microsoft Access and uses kriging to create surfaces. The surfaces were converted to Environmental Systems Research Systems (ESRI) ArcGIS grids. Map calculations were done on the grids to obtain the layer thickness.

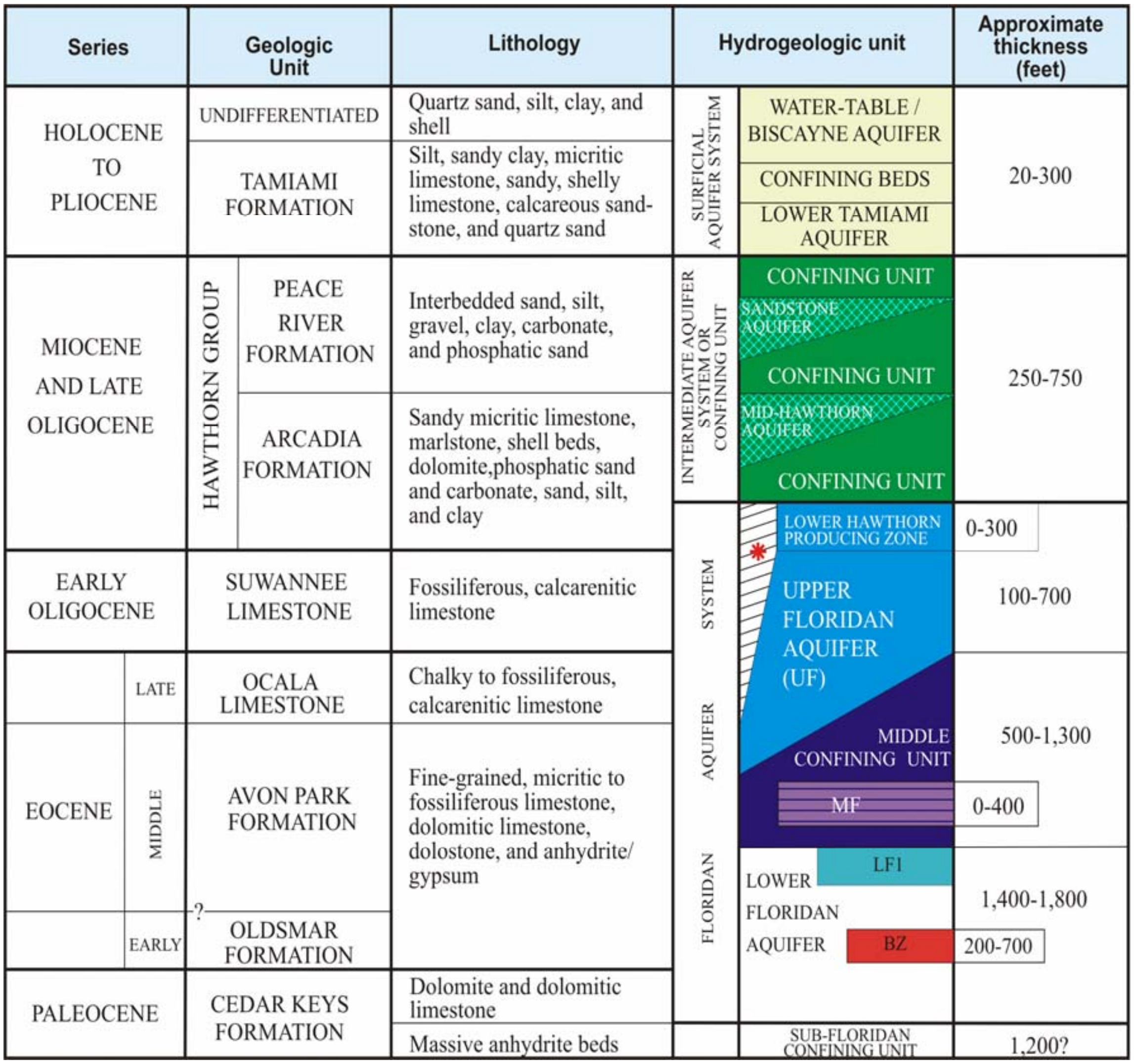

Figure 8. Relationship of Hydrogeologic Units in South Florida to Geologic Units and Their Lithology (Reese and Richardson 2004). *Geologic Units are missing in some areas.

Table 1. Schematic Cross-Reference to Cited Literature (Reese & Richardson 2004).

<table>
<tr><th>Thickness (feet) LKBGWM</th><th>Regional Study-ASR (Reese & Richardson2004)</th><th>SWFWMD (2000)</th><th>WRIR 02-4193 (O Reilly et al. 2002)</th><th>SFWMD TP 92-03 (Lukasiewicz 1992)</th><th>Miller 1986</th><th>Miller 1986</th></tr>
<tr><td>Lower Kissimmee Basin</td><td>Central, SW and SE Florida</td><td>Southwest Florida</td><td>East-Central Florida</td><td>Upper East Coast</td><td>Southwest Florida</td><td>Eastern and Southeast Florida</td></tr>
<tr><td>8-362</td><td>SU</td><td>SU</td><td>SU</td><td>SU</td><td>SU</td><td>SU</td></tr>
<tr><td>111-868</td><td>IC / IA</td><td>IC / IA</td><td>IC</td><td>IC</td><td>IC</td><td>IC</td></tr>
<tr><td>55-522</td><td>UF</td><td>UF - Upper Permeable Zone</td><td>UF - Zone A</td><td>UF</td><td rowspan="3">UF</td><td>UF</td></tr>
<tr><td>140-840</td><td>MS / MC1</td><td>MS</td><td rowspan="2">UF - Zone B</td><td>MS</td><td>Confining Unit I</td></tr>
<tr><td>92-246</td><td>MF</td><td>UF - Lower Permeable Zone</td><td>LF - Zone 1</td><td>LF</td></tr>
<tr><td>77-618</td><td>MC2</td><td>MC or SFCU</td><td>MS / MC</td><td>LC</td><td>Confining Unit II</td><td>Confining Unit VI</td></tr>
<tr><td></td><td>LF1</td><td>LF (where present)</td><td>LF - Zone 1</td><td>LF - Zone 2</td><td>LF</td><td>LF</td></tr>
<tr><td></td><td>LC</td><td></td><td>LC</td><td>LC</td><td>Confining Unit VI</td><td>Confining Unit VIII</td></tr>
<tr><td></td><td>LF2 (LF3, etc.)</td><td></td><td>LF - Zone 2</td><td></td><td>LF</td><td>LF</td></tr>
<tr><td></td><td>BZ</td><td>BZ (where present)</td><td></td><td>BZ</td><td>BZ</td><td>BZ</td></tr>
</table>

SU	Surficial Aquifer System
IC / IA	Intermediate Confining and/or Intermediate Aquifer System
UF	Upper Floridan Aquifer
MS / MC1	Upper Middle Semi and/or Confining Unit
MF	Middle Floridan Aquifer
MC2	Lower Middle Confining Unit (SFCU is Sub-Floridan Confining Unit)
LF1	Lower Floridan Aquifer - first permeable zone.
LC	Lower Confining Unit
Confining Unit VIII	Confining Units from Miller, 1986 - not always continuous within region. LF2, LF3, etc. are deeper permeable zones within the Lower Floridan Aquifer.
BZ	Boulder Zone - not continuous across study area

Figure 9 shows the location of several cross-sections showing the relative extent and thickness of the hydrostratigraphic units used in the Lower Kissimmee Basin Groundwater Model. **Figures 10** to **14** correspond to the lines in the base map of **Figure 9**. All the cross sections were created using VIEWLOG.

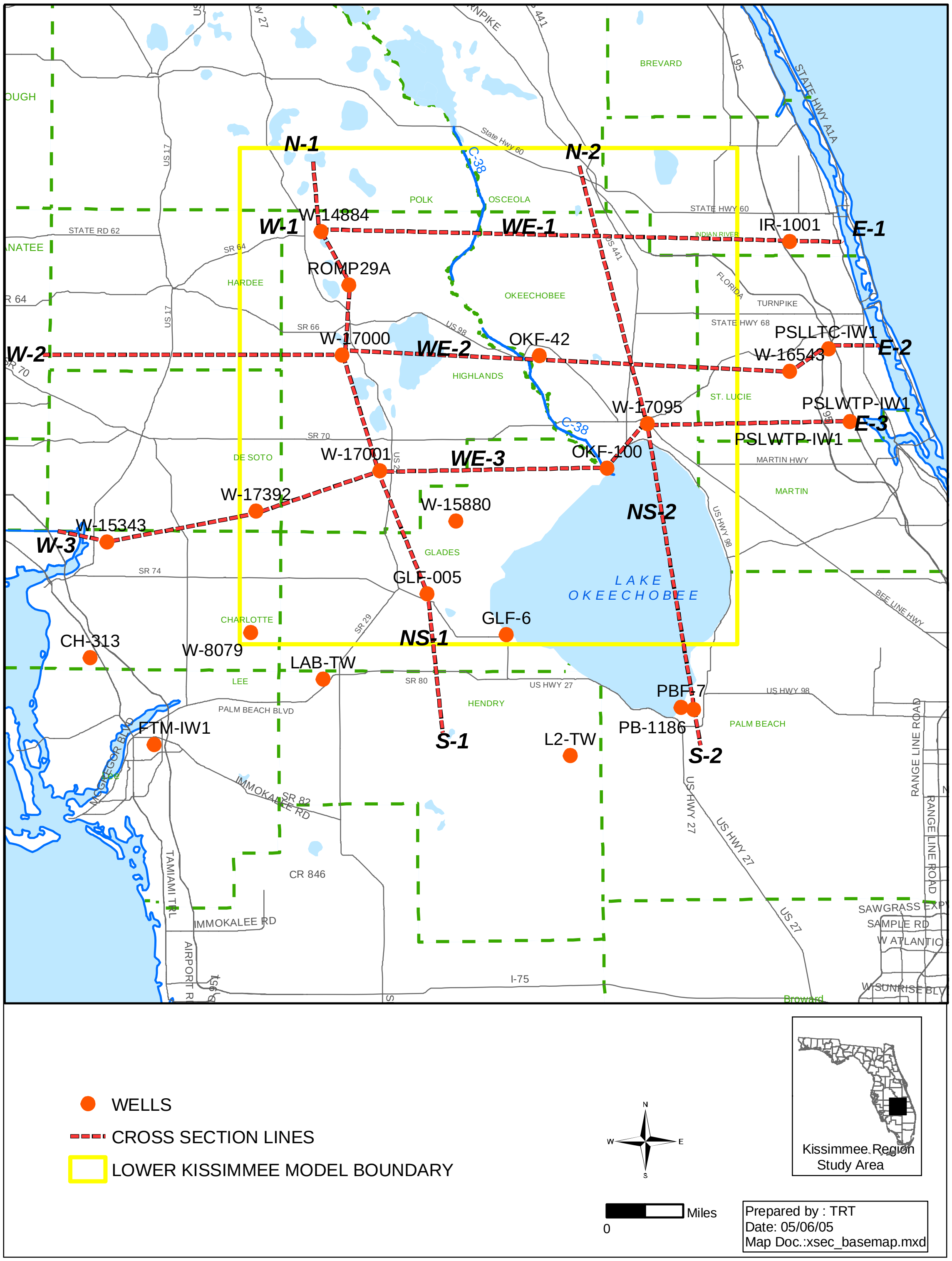

Figure 9. Base Map for Cross Sections.

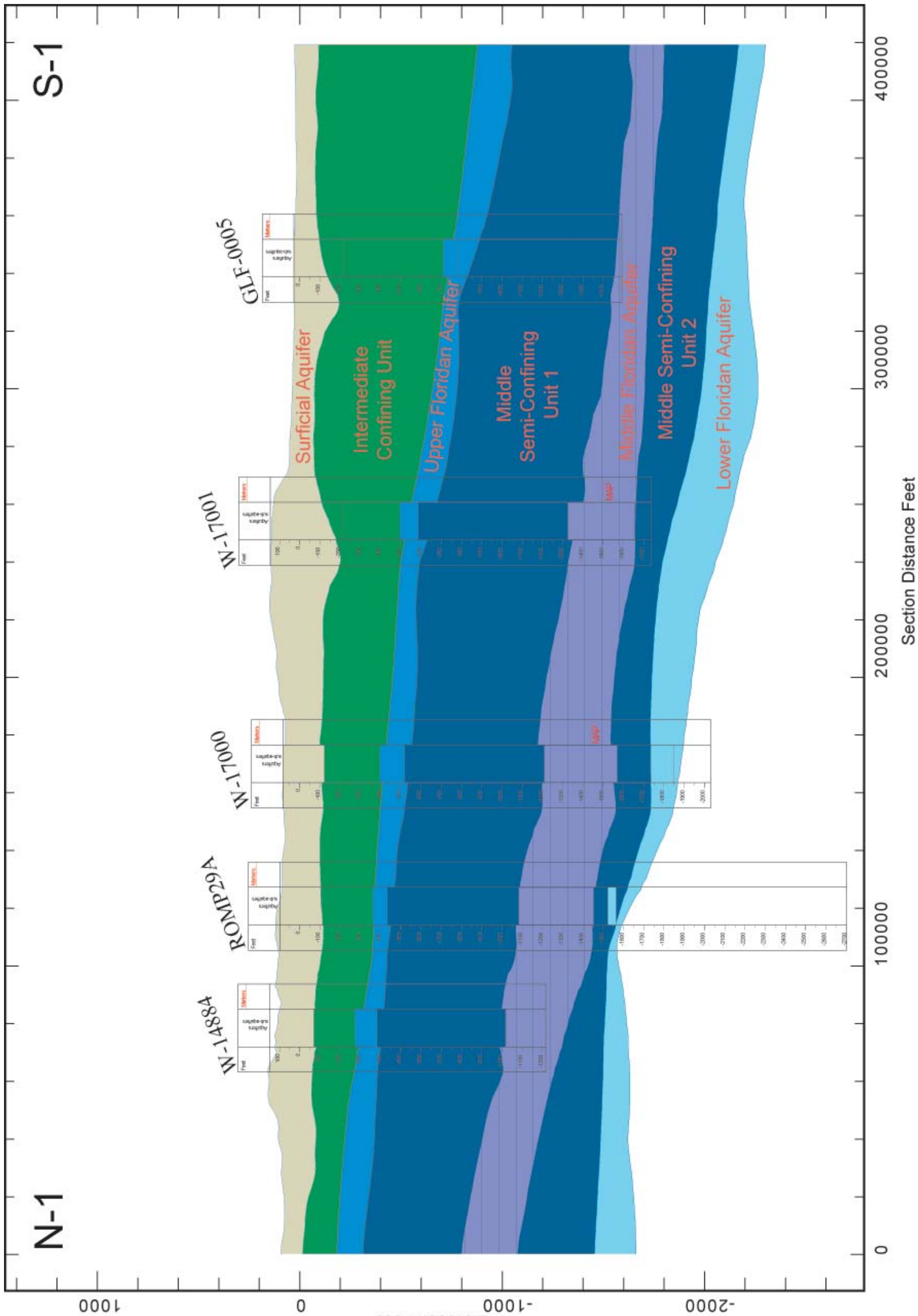

Figure 10. North South Cross Section 1 (Source Data is a Subset of Data from Reese & Richardson 2004).

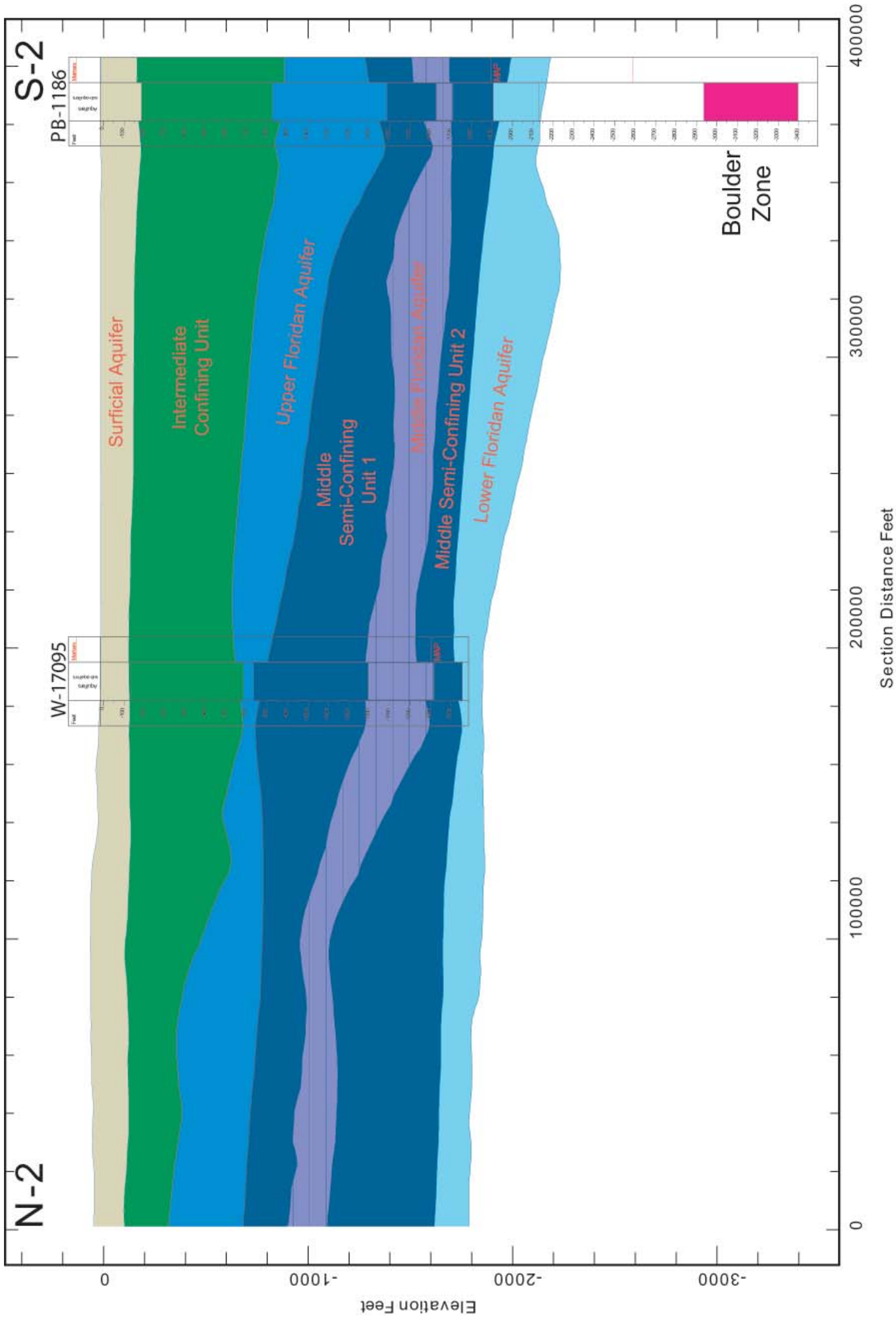

Figure 11. North South Cross Section 2 (Source Data is a Subset of Data from Reese & Richardson 2004).

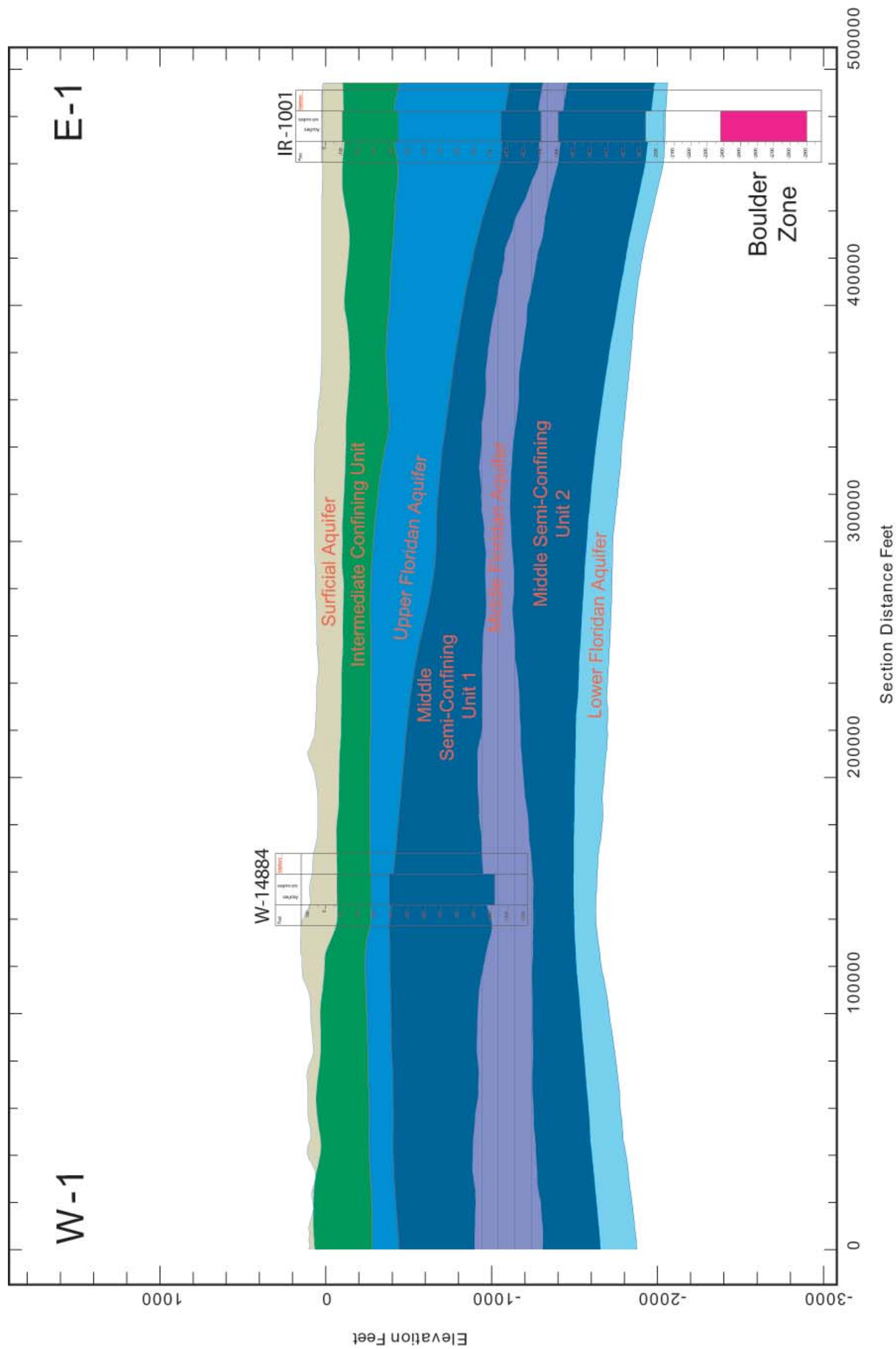

Figure 12. West East Cross Section 1. (Source Data is a Subset of Data from Reese & Richardson 2004).

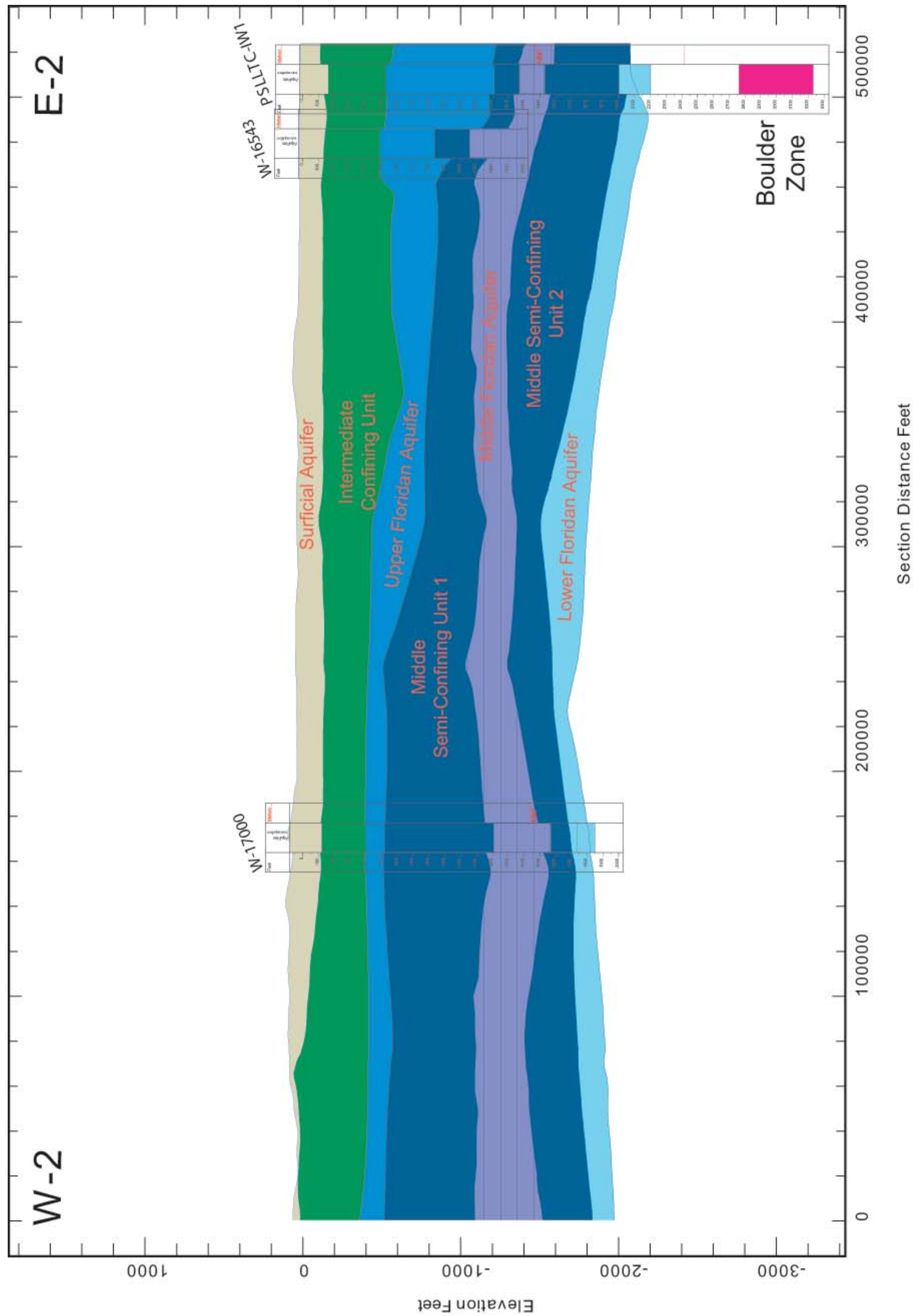

Figure 13. West East Cross Section 2. (Source Data is a Subset of Data from Reese & Richardson 2004).

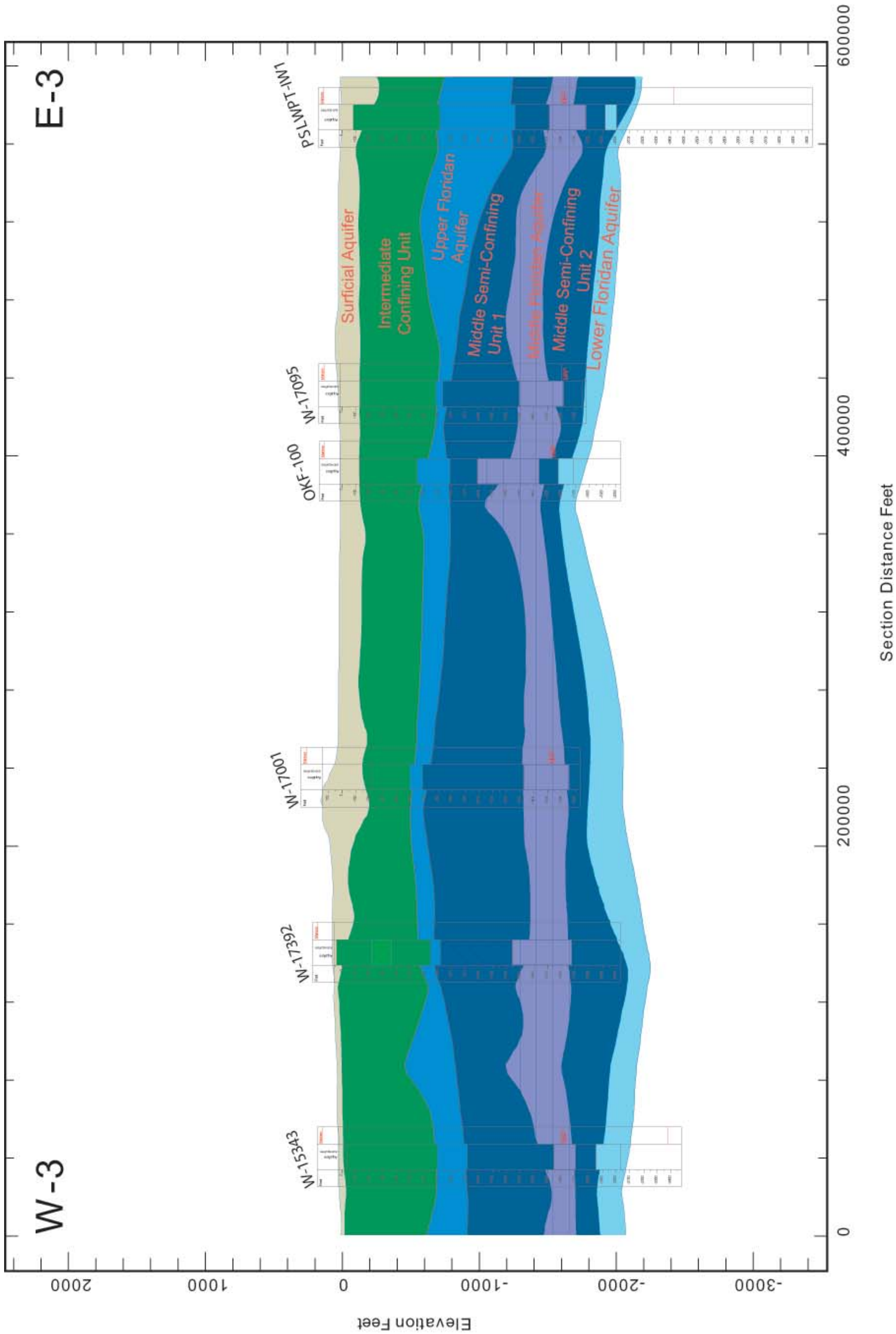

Figure 14. West East Cross Section 3. (Source Data is a Subset of Data from Reese & Richardson 2004).

Surficial Aquifer System

The Surficial Aquifer System is unconfined and consists of fine-to-medium grained quartz sand with varying amounts of silt, clay and crushed shell, of Holocene and Pleistocene age. This uppermost part of the Surficial Aquifer System is also called the Water Table Aquifer. The Surficial Aquifer System produces small quantities of good-to-fair quality water. It is generally soft, low in mineral content, slightly corrosive and often high in color and iron. The thickness of the Surficial Aquifer System varies from 8 to 362 feet in the model area.

Figures 15 and **16** show the bottom and thickness of the Surficial Aquifer System in the model domain. Station W-16969 in Okeechobee County has an average hydraulic conductivity K=41 ft/day. While W-16970 K=28 ft/day and W-16950 showed K=8 ft/day (DBHYDRO). Yobbi (1996) cited K values in the range of 2–8 ft/day for aquifer tests in Lake Wales Ridge. The hydraulic data for the model area were very limited so data from north of the model area in Lake Tohopekaliga were also looked at. The average hydraulic conductivity (K) there was 7 ft/day (Valdez 2000). The hydraulic conductivity for the Surficial Aquifer System was estimated at 14 ft/day for most of the model area. Originally higher values were estimated, resulting in water levels that were too low. The lower value of 14 ft/day was in the range of measured values and improved the calibration of the water levels in the Surficial Aquifer System. The river and lake area were set at 50 ft/day and were modified in Avon Park Ridge for calibration purposes. See **Figure 49** for the distribution of the hydraulic conductivities in the area.

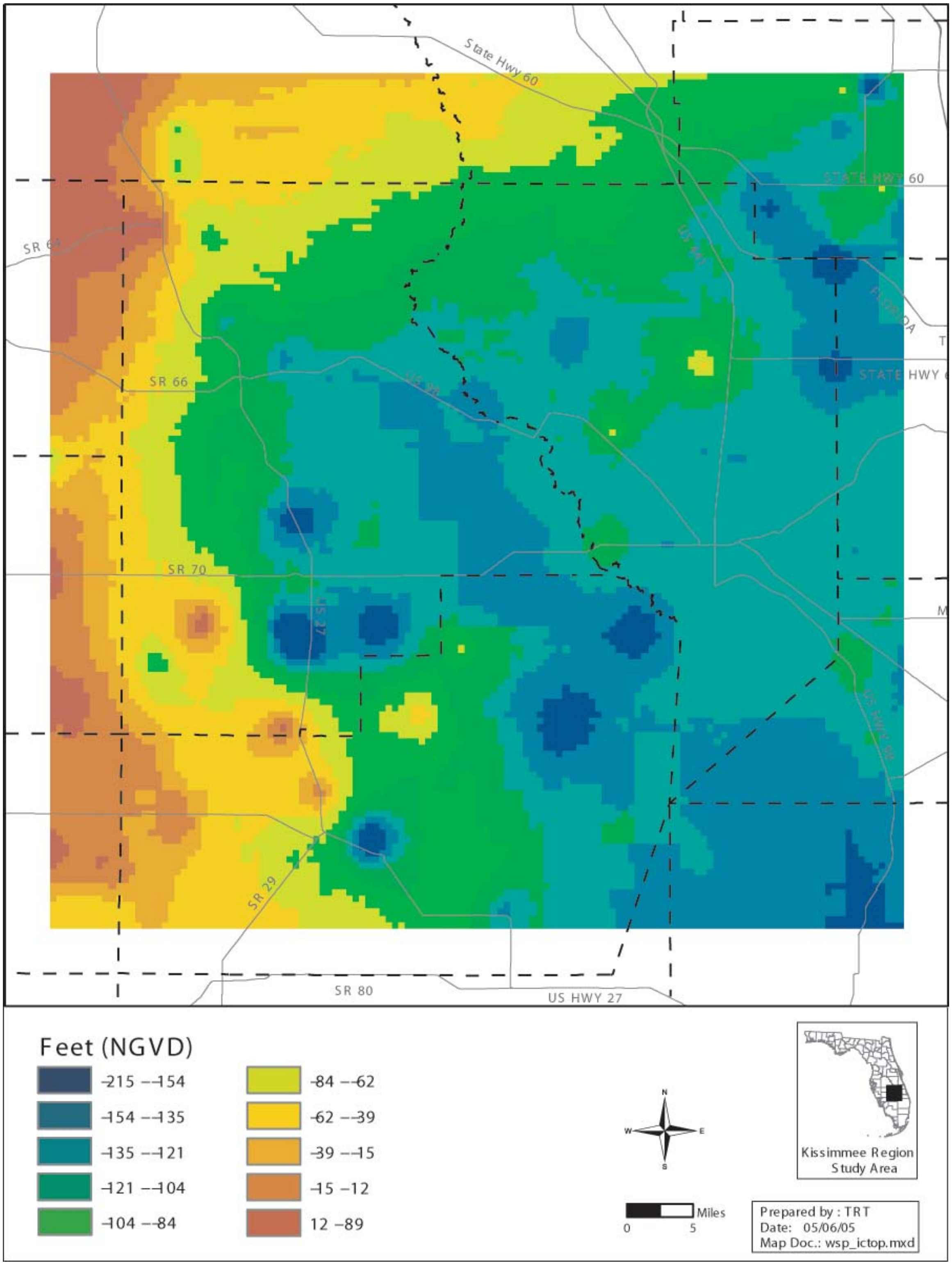

Figure 15. Elevation of the Base of the Surficial Aquifer System (Subset of Data Mapped in Reese & Richardson 2004).

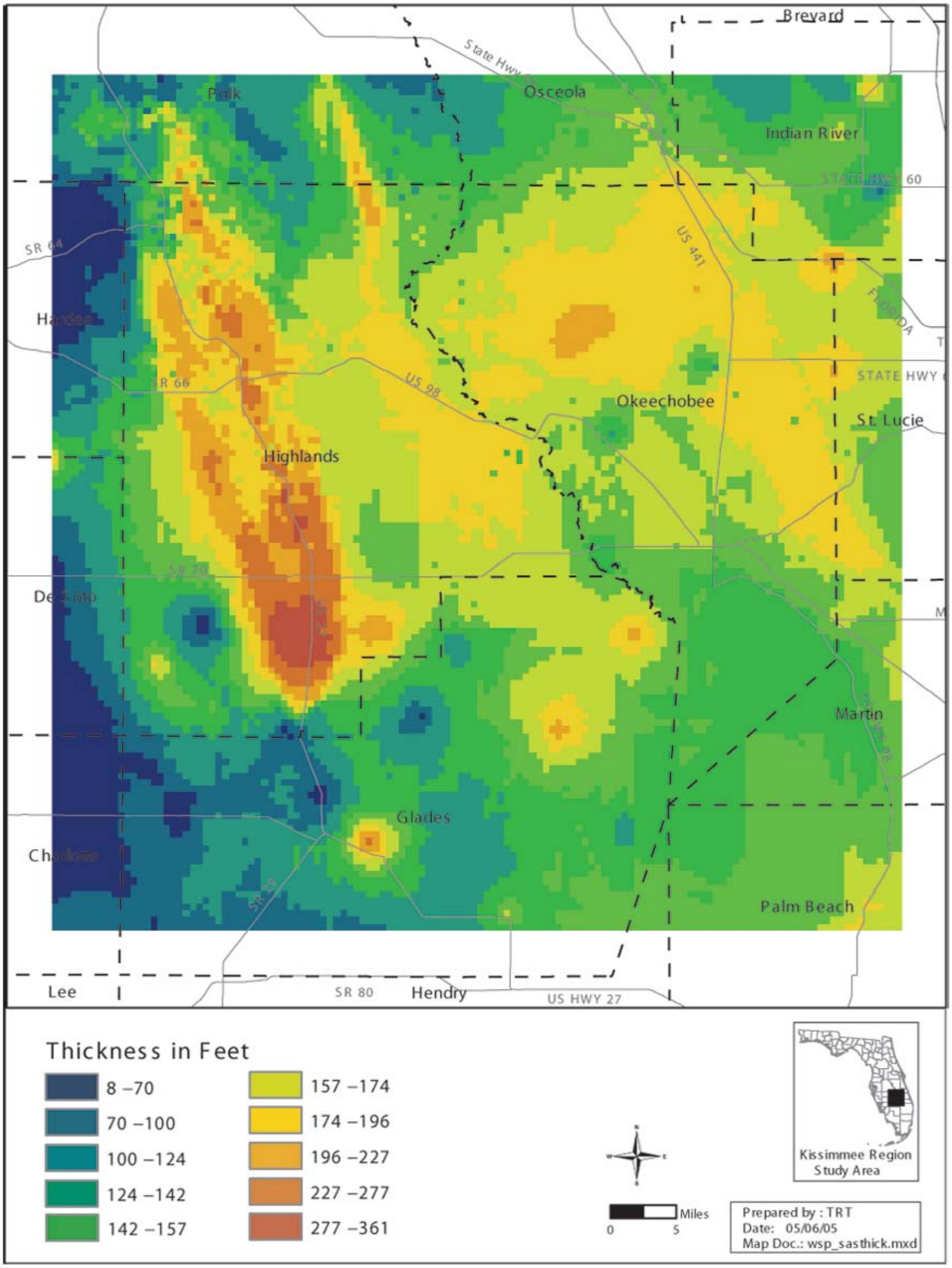

Figure 16. Thickness of the Surficial Aquifer System.

Intermediate Confining Unit

The Hawthorn Group of sediments consists of carbonate rocks inter-bedded with phosphatic silt, sand, clay and limestone. There is an unconformity that separates the Hawthorn Group from the Suwannee limestone below. There are a few minor permeable units within the Intermediate Aquifer System in the study area, but most of unit has very poor productivity. The Intermediate Confining Unit serves as a confining barrier between the Surficial Aquifer System and the Floridan Aquifer System for a large portion of the model area. The thickness of the Intermediate Confining Unit is highly variable. Along Lake Wales Ridge there are sinkhole depressions where the Intermediate Confining Unit is thin and it pinches out north of the model area in Polk Count (O'Reilly 2002, Choquette 2000, Yobbi 1996). The Intermediate Confining Unit thickens southward. Preliminary data from Krupa *et al*. 2005 shows that the Kissimmee River Valley has higher levels of connectivity between the Surficial Aquifer System and the Upper Floridan Aquifer System. **Figures 17** and **18** show the bottom and thickness of the Intermediate Confining Unit.

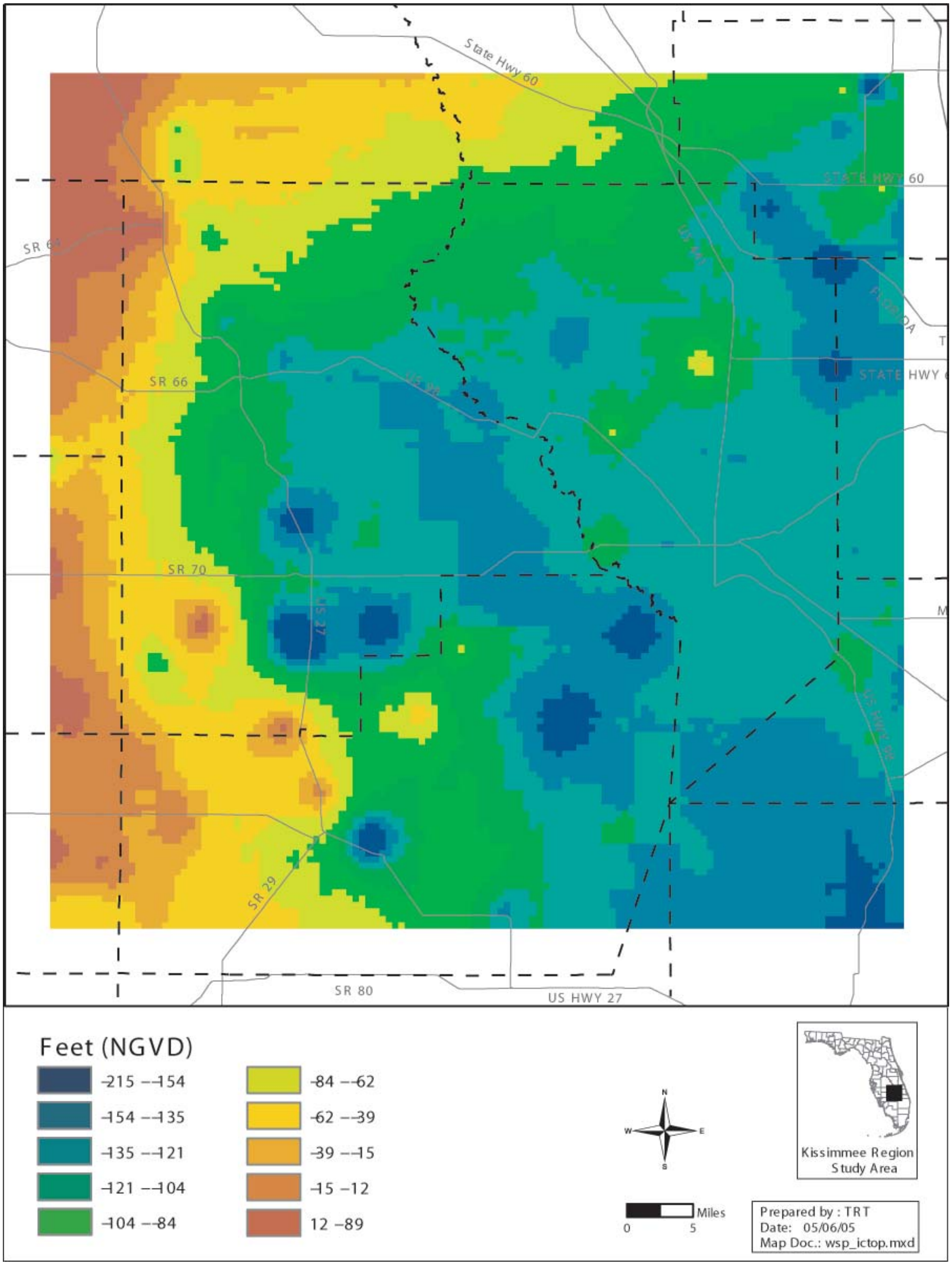

Figure 17. Elevation of the Top of the Intermediate Confining Unit (Subset of Data Mapped in Reese & Richardson 2004).

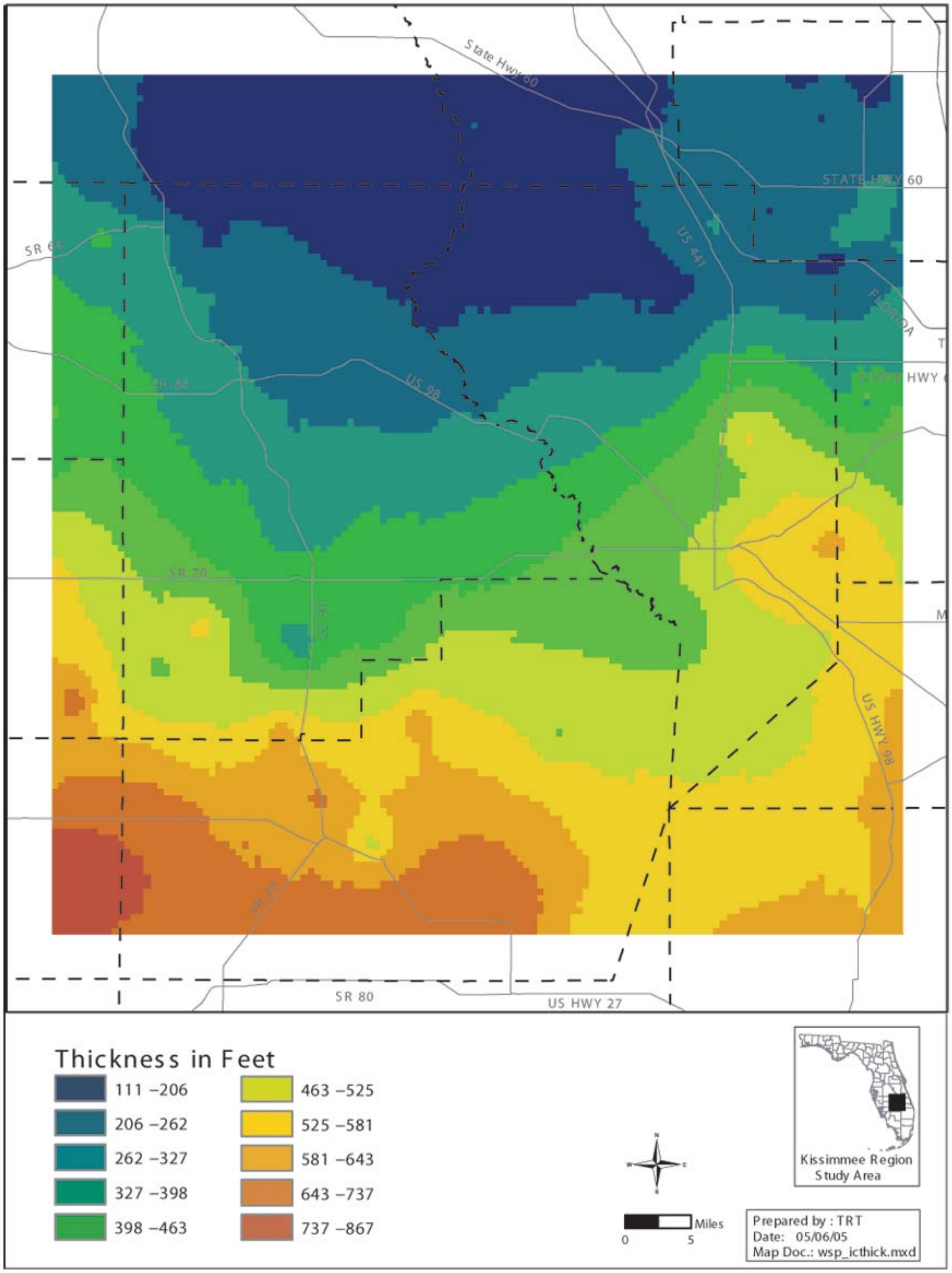

Figure 18. Thickness of the Intermediate Confining Unit.

Floridan Aquifer System

The Floridan Aquifer System is a thick system consisting of the Upper, Middle and Lower Floridan aquifers, separated by confining units. The Upper and Middle Floridan aquifers are the main production zones for consumptive use purposes. There are no wells that penetrate the Lower Floridan Aquifer in the model area. The Floridan Aquifer System is a confined system, with the exception of some sinkholes along Lake Wales Ridge (Beach and Chan 2003). The Floridan Aquifer System is composed of a thick sequence of carbonate rocks over lain by clastic sedimentary layers in the Intermediate and Surficial Systems.

Upper Floridan Aquifer

The Upper Floridan Aquifer begins with the Suwannee Limestone, and the base often coincides with the top of the Avon Park Formation and is marked with a drop in the permeability Reese and Richardson (2004). The transmissivity map presented in Reese and Richardson (2004) was used for the Lower Kissimmee Groundwater Model area. Due to the limited amount of aquifer performance tests in the model region the kriging program generated some low and negative values. All values less than 1,000 ft^2/day were assigned the value of 1,000 ft^2/day. The transmissivity range of the Upper Floridan Aquifer is 1,000 ft^2/day to 72,250 ft^2/day, **Figures 19** and **20** show the top and thickness of the Upper Floridan Aquifer. **Figure 21** displays the transmissivity

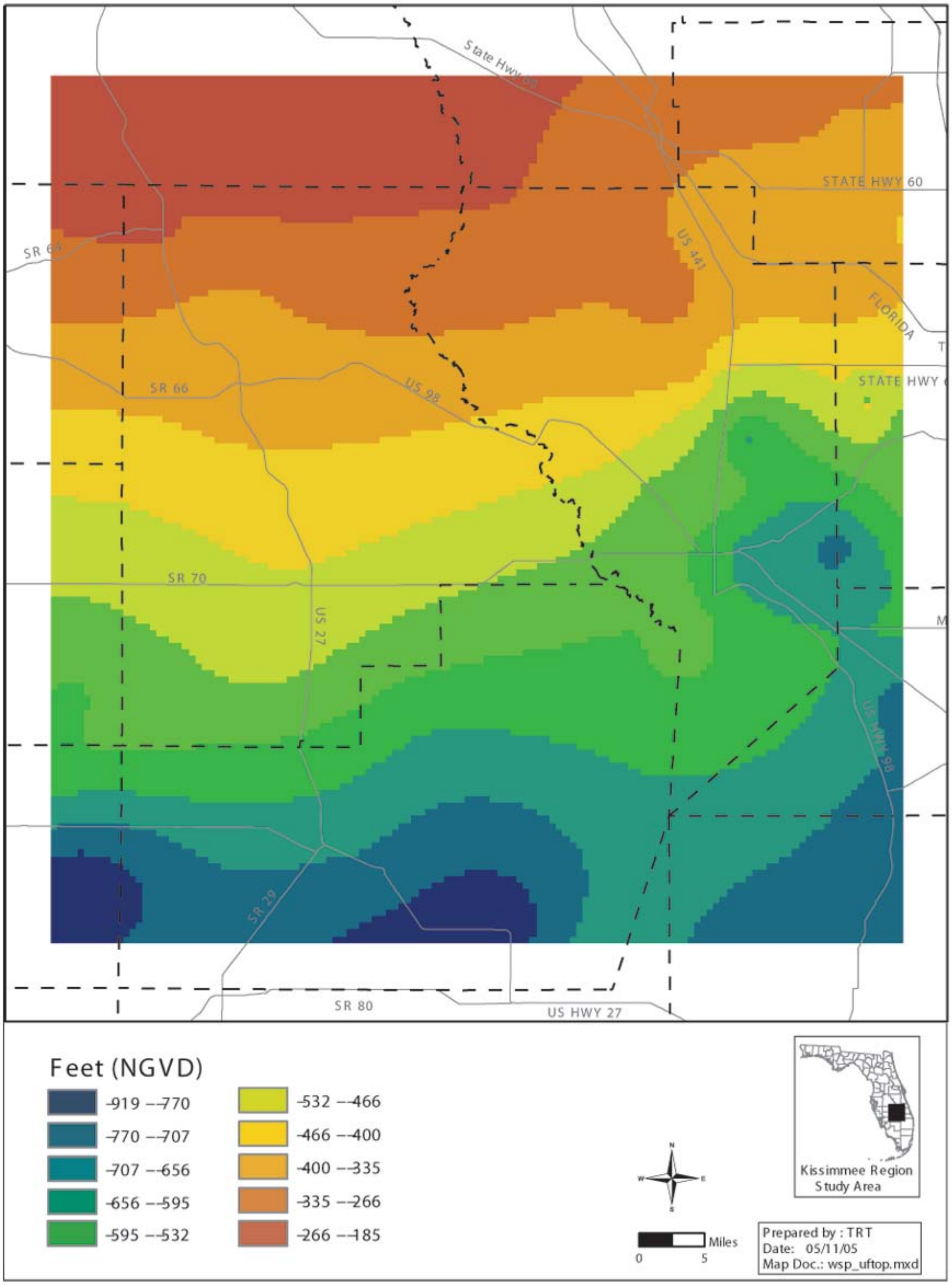

Figure 19. Elevation of the Top of the Upper Floridan Aquifer (Subset of Data Mapped in Reese & Richardson 2004).

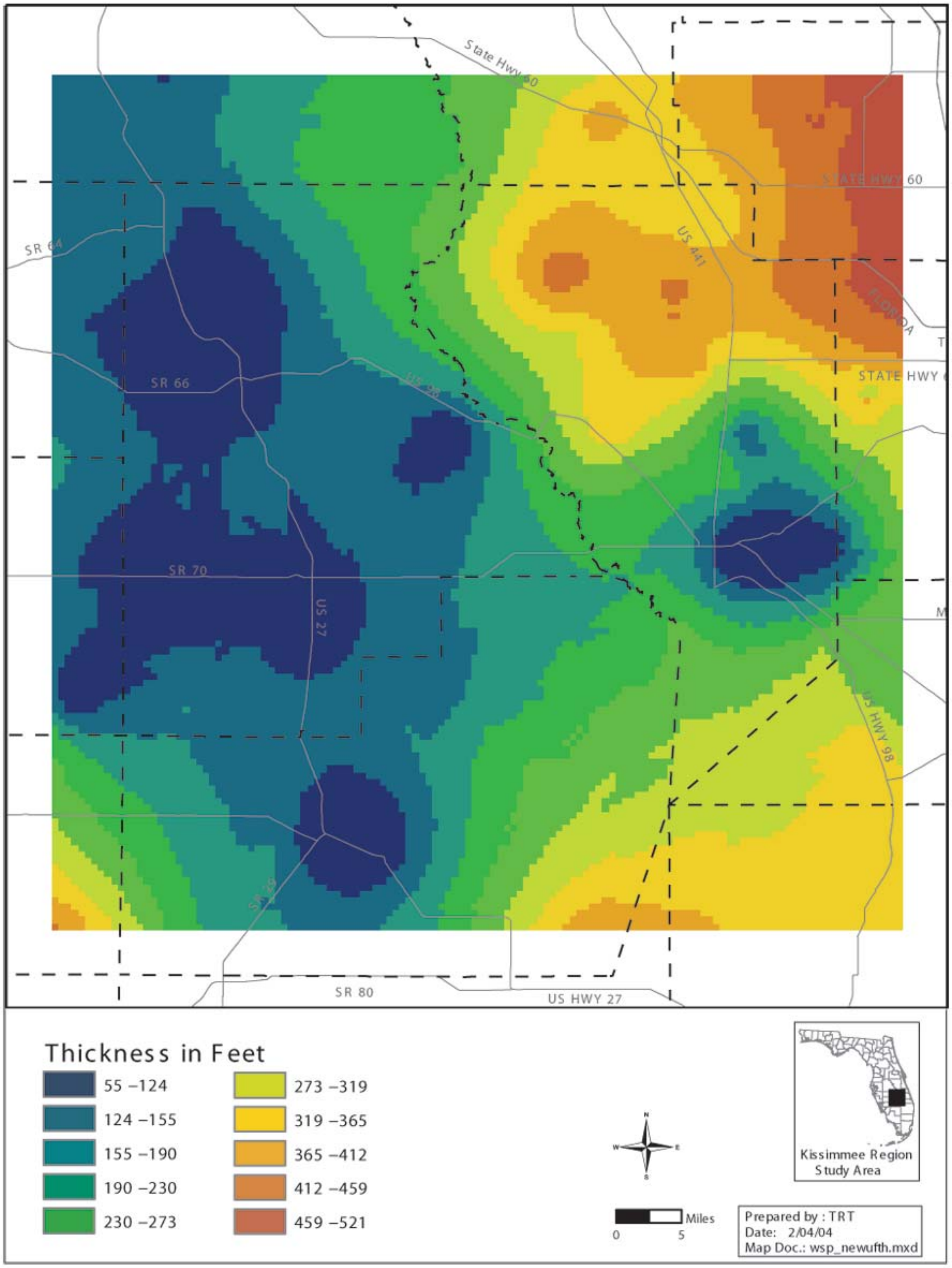

Figure 20. Thickness of the Upper Floridan Aquifer.

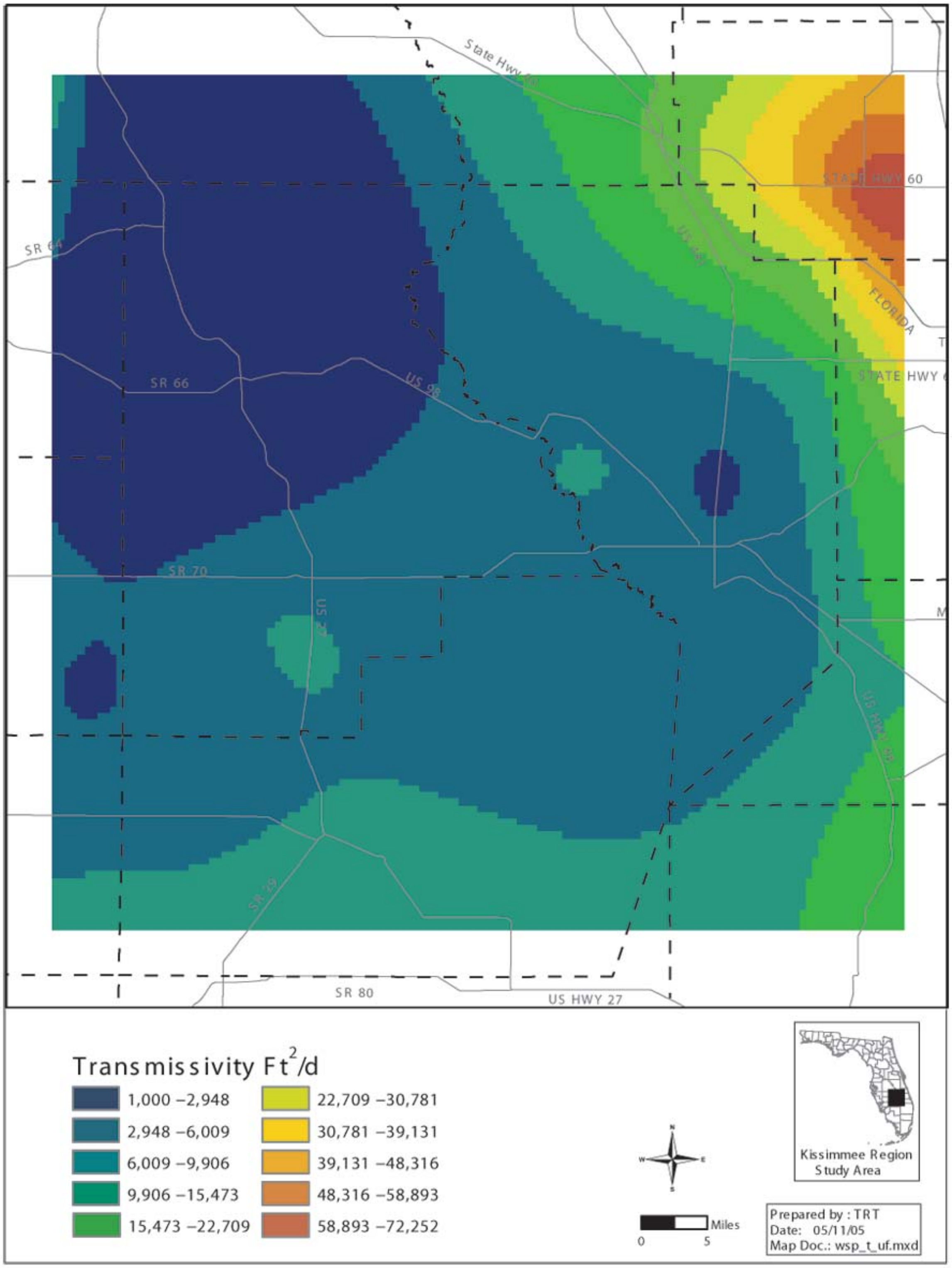

Figure 21. Transmissivity in the Upper Floridan Aquifer (ft^2/day) (Subset of Data Mapped in Reese & Richardson 2004).

Middle Confining Unit 1

The top of the Middle Confining Unit 1 (MC1) is often identified as the top of the Ocala Limestone (Reese and Richardson (2004). The unit is composed of fine-grained, poorly cemented limestone of relatively low permeability. The confining unit may be fractured in some areas (Reese and Richardson 2004). Hickey (1990) noted upward flow through the Middle Confining Unit. The thickness varies from 140 to 840 feet. **Figures 22** and **23** show the top and thickness of the Middle Confining Unit.

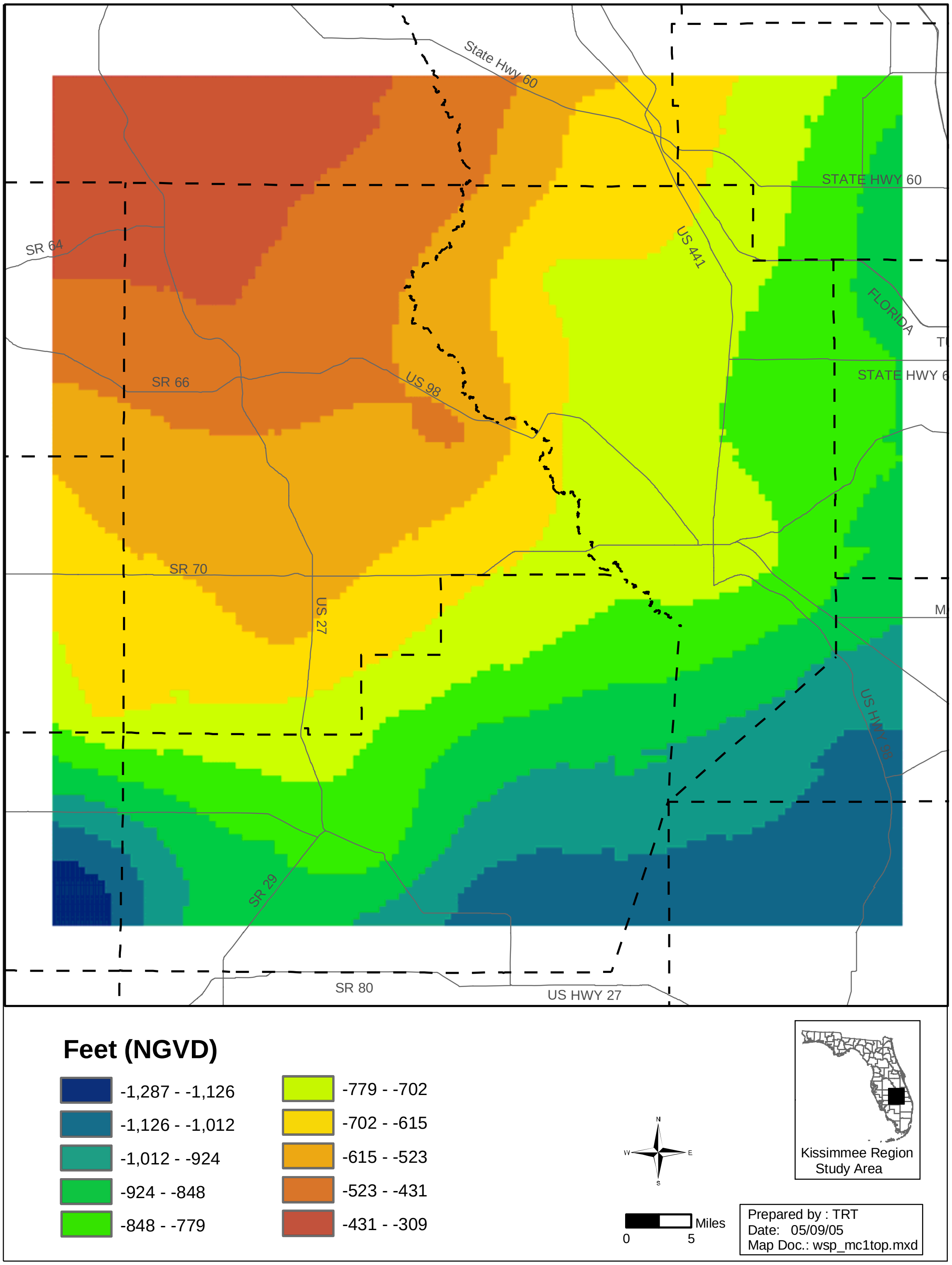

Figure 22. Elevation of the Top of the Middle Confining Unit 1 (Subset of Data Mapped in Reese & Richardson 2004).

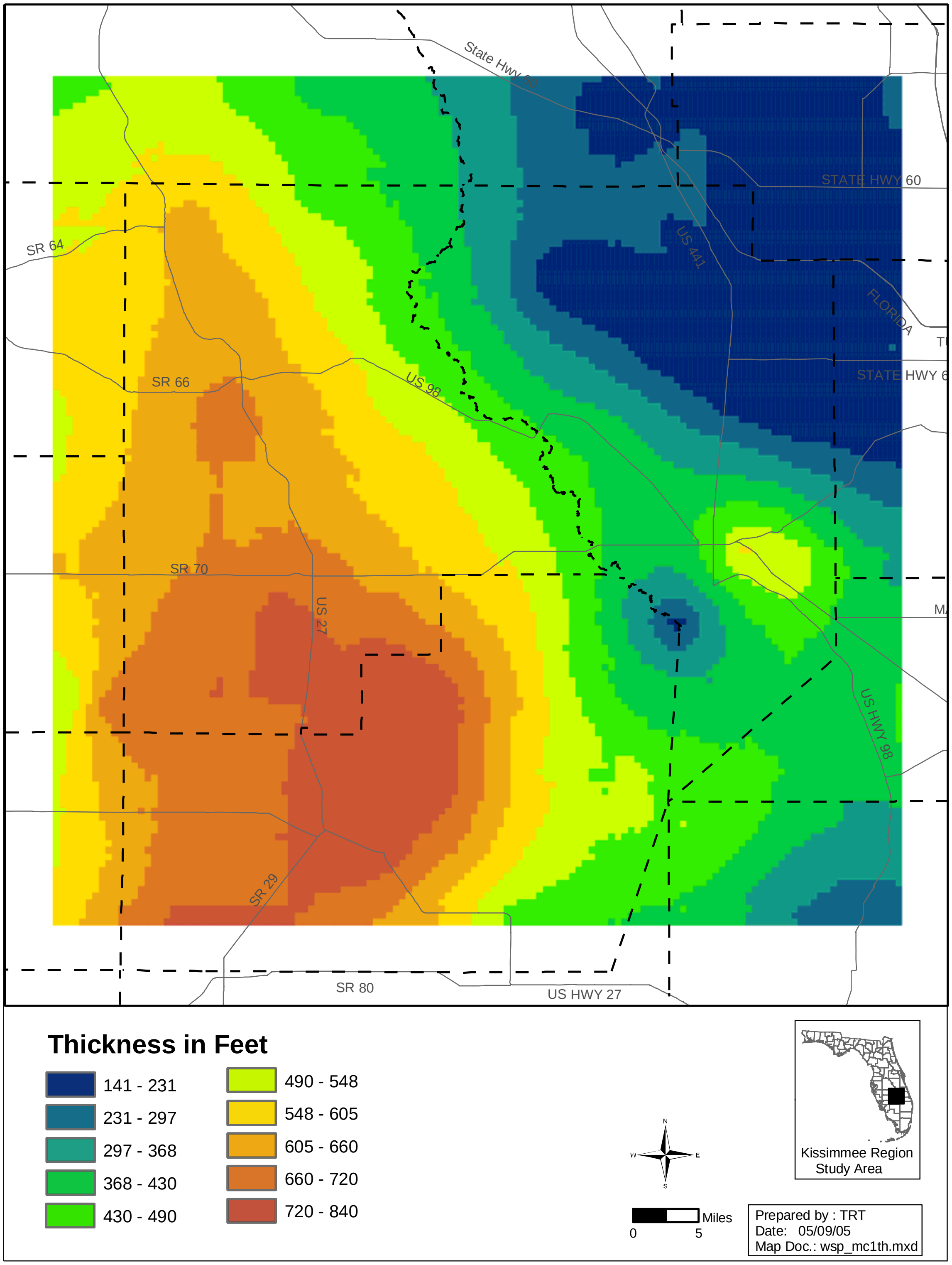

Figure 23. Thickness of the Middle Confining Unit 1.

Middle Floridan Aquifer

The Middle Floridan Aquifer begins no higher than the top of the Avon Park Formation and usually does not extend beyond the Middle Avon Park Formation (Reese and Richardson 2004). The Middle Floridan Aquifer is a thick permeable and highly transmissive dolostone sequence, previously included within the Lower Floridan Aquifer (Lukasiewicz 1992) as Upper Floridan Zone B (Beach and Chan 2003), or the lower permeable zone, or lower part of the Upper Floridan. Reese and Richardson (2004) reviewed the previous studies and identified the Middle Floridan as a highly permeable unit that is regionally continuous. The dolostone sequence is fractured and cavernous permeability can also be present (Reese and Richardson 2004). In the model area, the thickness of the Middle Floridan Aquifer varies from 92 to 446 feet. The transmissivities in the Middle Floridan Aquifer range from 25,766 (ft^2/day) up to 1,272,354 (ft^2/day). This aquifer is sometimes referred to as the High T Zone (Beach and Chan 2003).

Figures 24, **25 and 26** show the top, thickness and transmissivity of the Middle Floridan Aquifer.

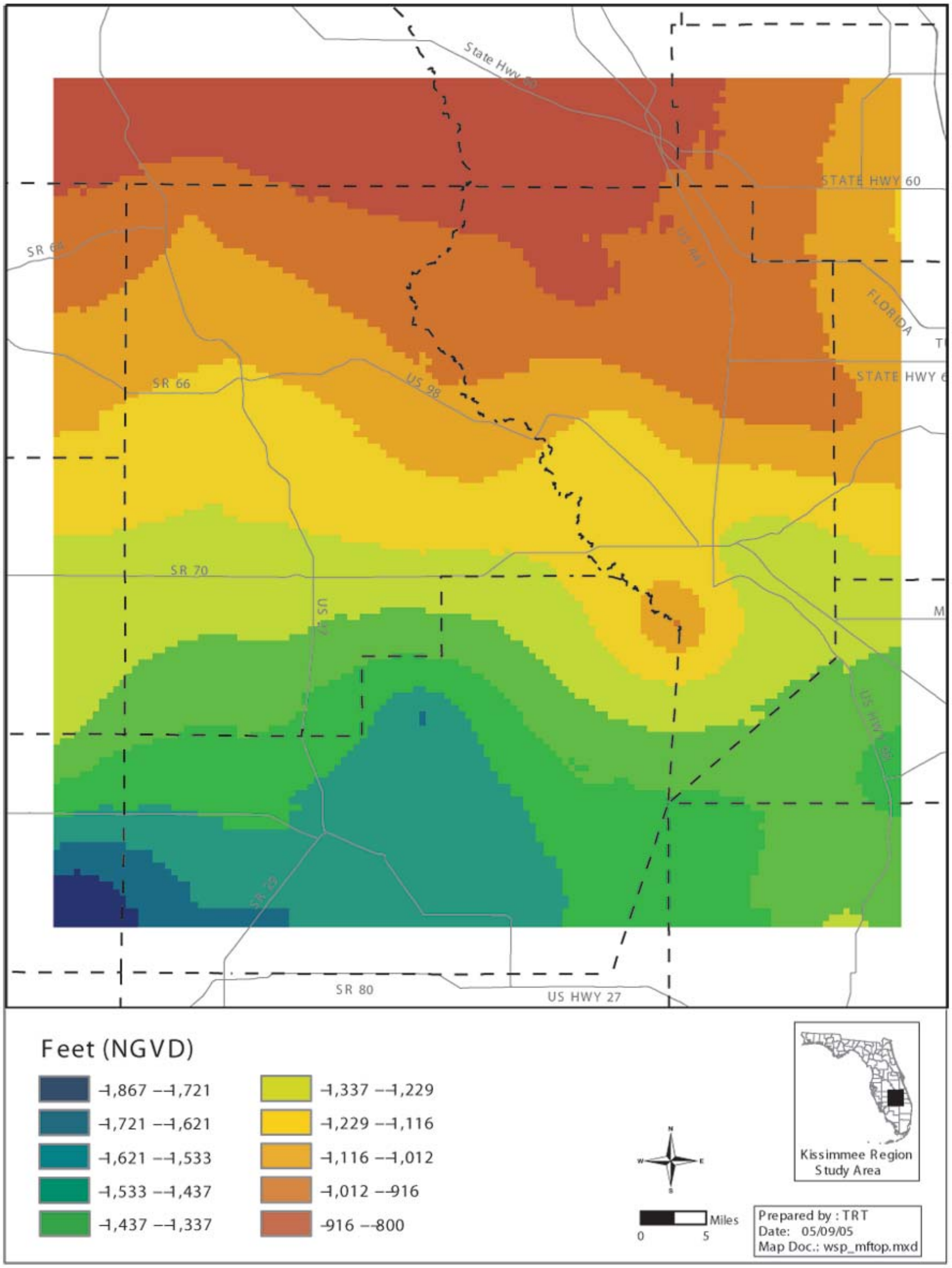

Figure 24. Elevation of the Top of the Middle Floridan Aquifer (Subset of Data Mapped in Reese & Richardson 2004).

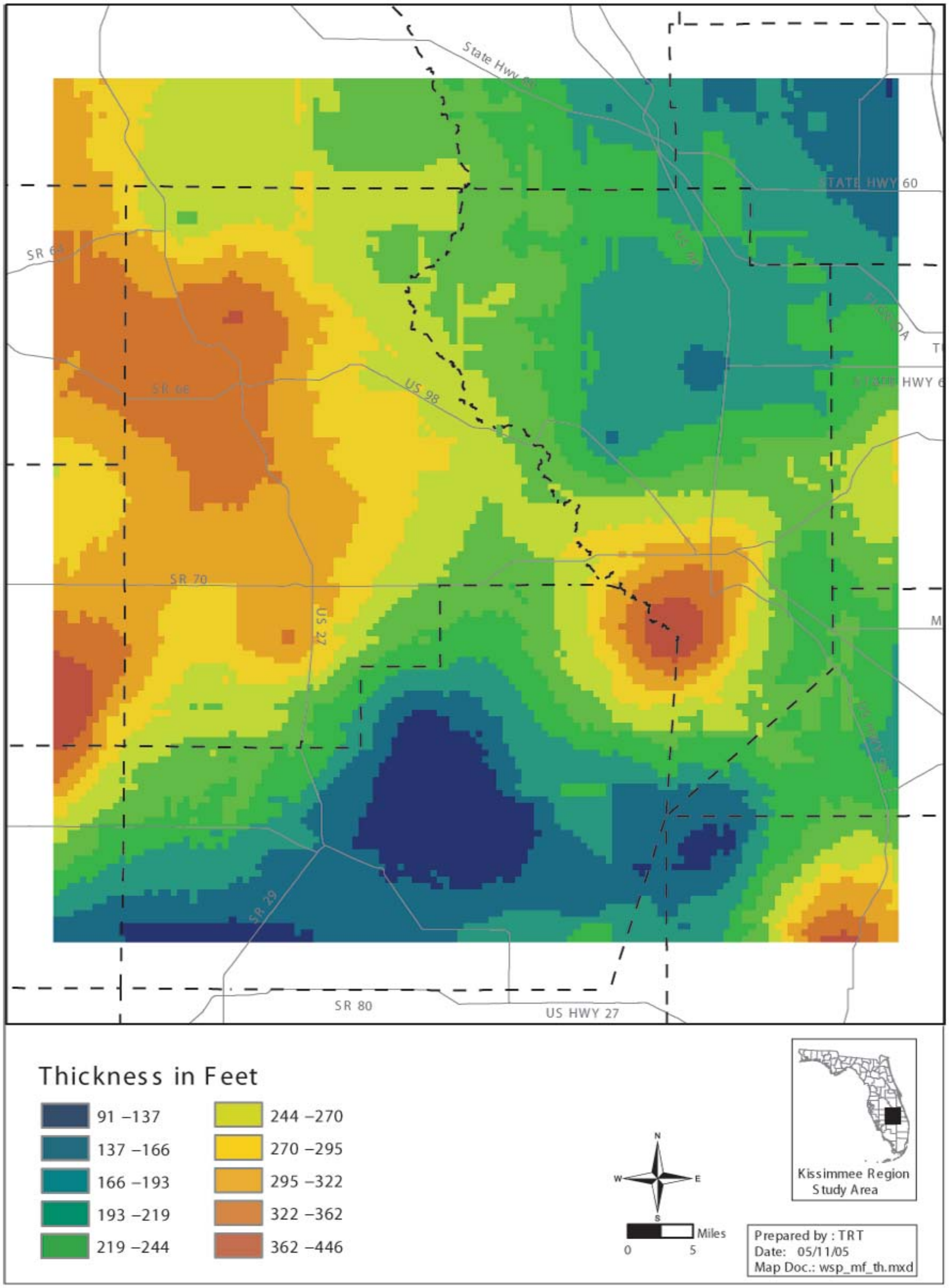

Figure 25. Thickness of the Middle Floridan Aquifer.

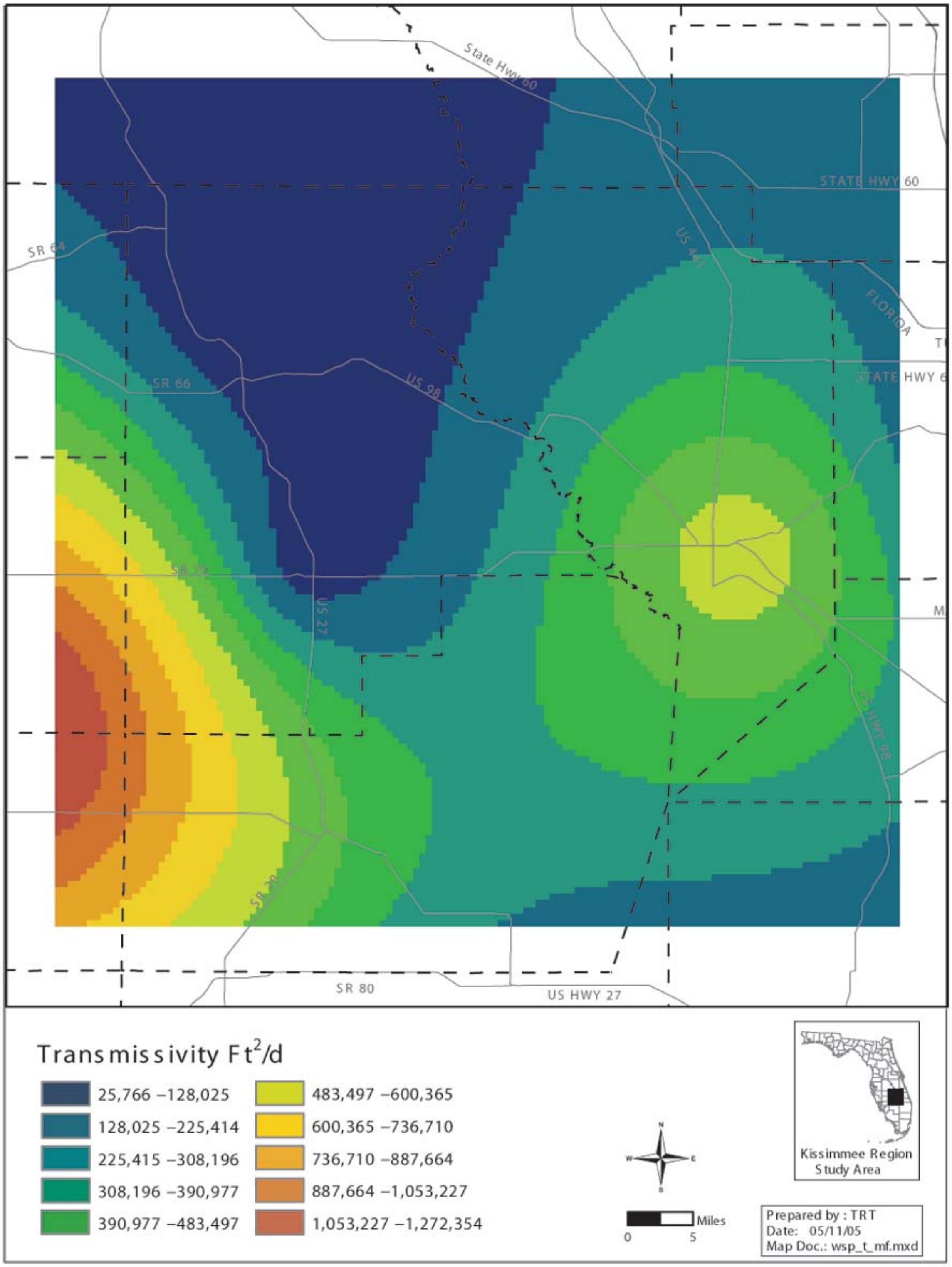

Figure 26. Transmissivity in the Middle Floridan Aquifer (ft^2/day) (Subset of Data Mapped in Reese & Richardson 2004).

Middle Confining Unit 2

The Middle Confining Unit 2 (MC2) is comprised of a thin dense dolomite unit in the Middle Avon Park Formation. In the model area, the thickness varies from 77 to 618 feet. In some locations, the confining unit may be fractured. **Figures 27** and **28** show the top and thickness of the Middle Confining Unit 2.

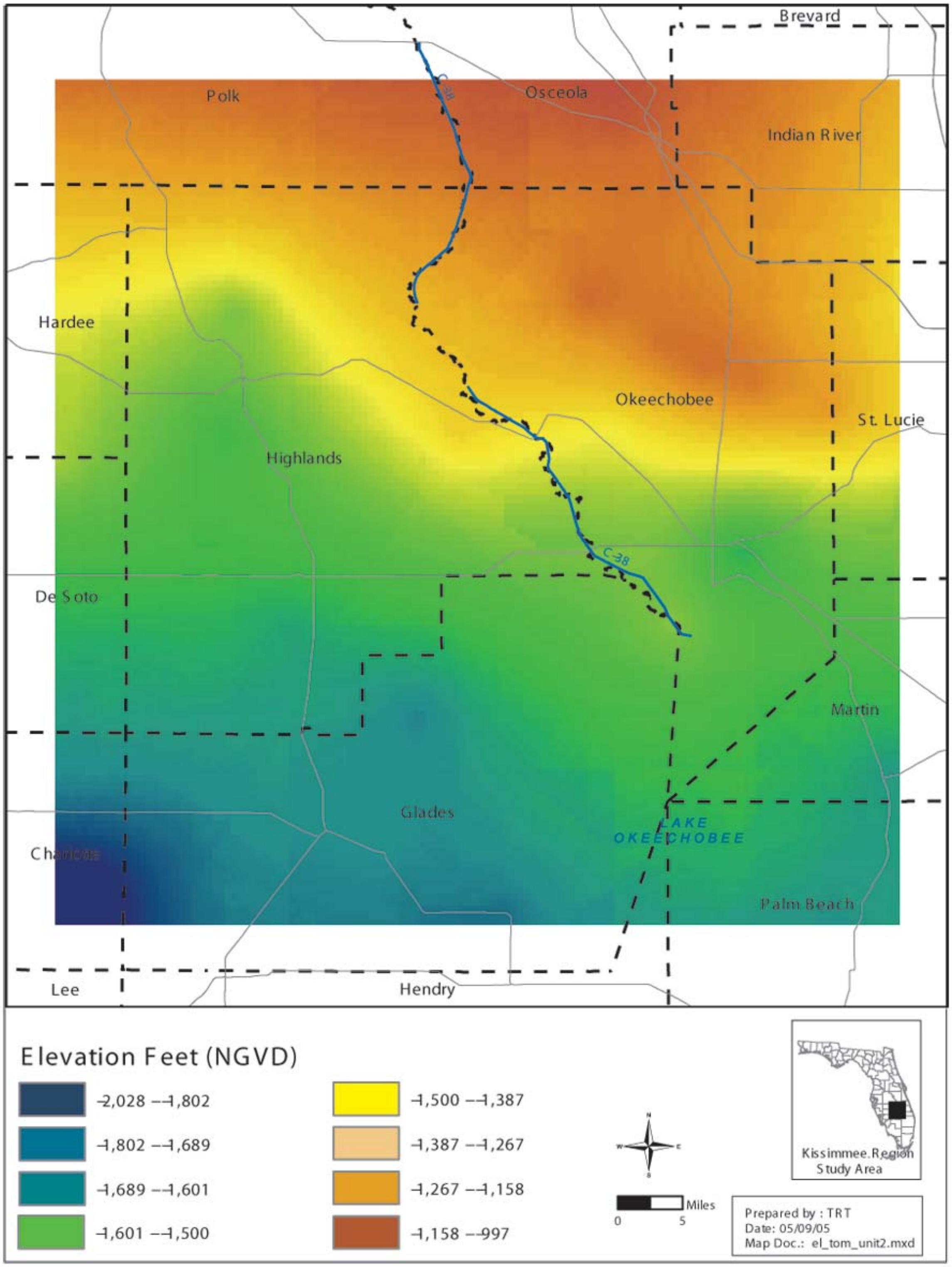

Figure 27. Elevation of Top of Middle Confining Unit 2 (Subset of Data Mapped in Reese & Richardson 2004).

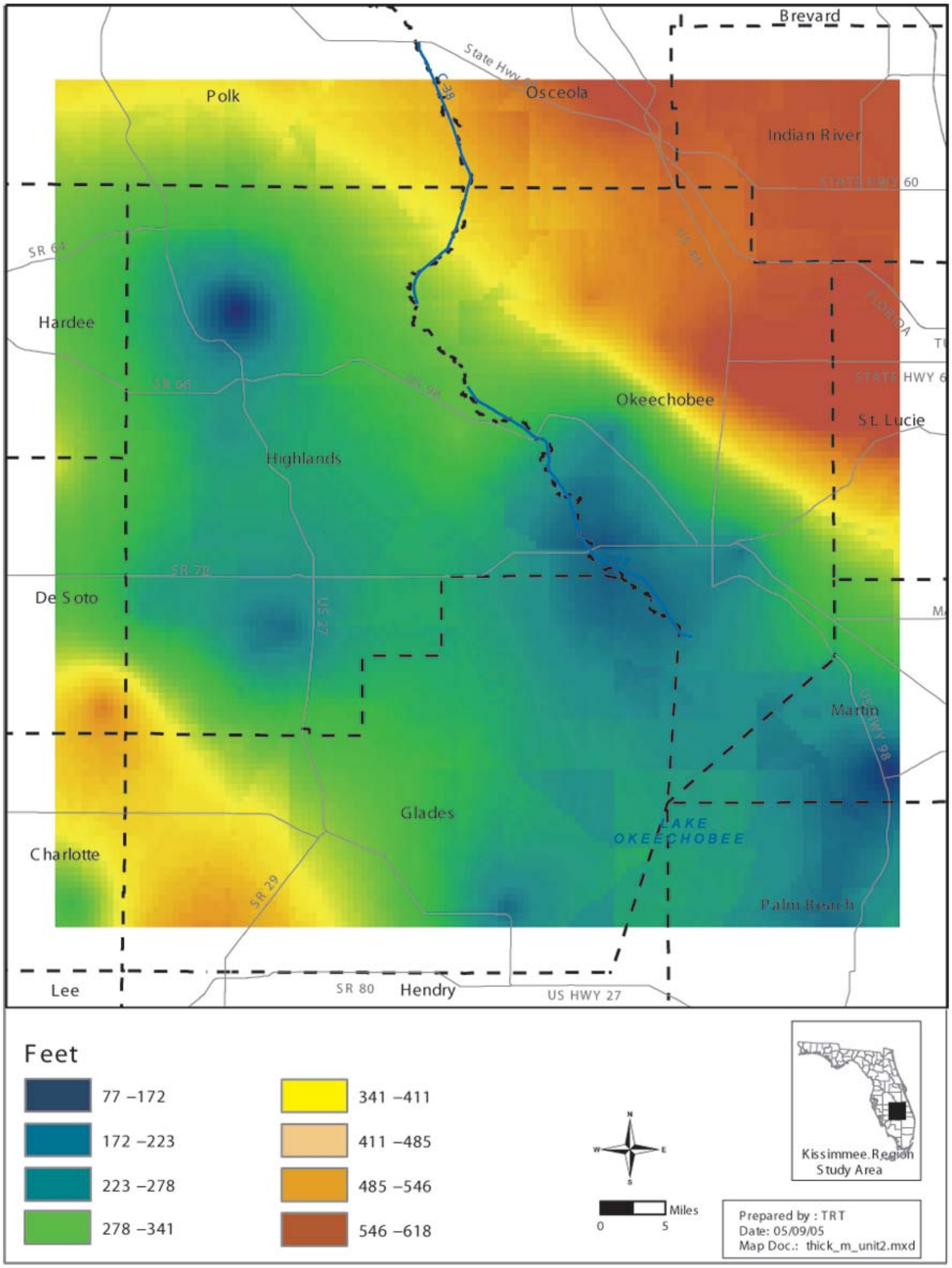

Figure 28. Thickness of the Middle Confining Unit 2.

Lower Floridan Aquifer

The top of the Lower Floridan Aquifer (LF) is the lower part of the Avon Park Formation. Included in the Lower Floridan Aquifer are the Oldsmar and Cedar Key Formations. It is identified as the first permeable zone below the Middle Confining Unit 2. The base of the Floridan Aquifer System is composed of a low permeability dolomite with gypsum layer. The dolostone in the Lower Floridan Aquifer, however, tends to be dense, massive and crystalline. It is not fractured as in the Middle Floridan Aquifer. Confinement between the Middle Floridan Aquifer and Lower Floridan Aquifer may not exist in some areas (Reese and Richardson 2004). There are no geophysical logs of Lower Floridan Aquifer wells in the model area to verify the local conditions. **Figure 29** shows the top of the Lower Floridan Aquifer .The transmissivity for the Lower Floridan Aquifer was estimated to be 300,000 (ft^2/day) based on lower Floridan sites outside the model boundary and calibrated model values presented in Sepulveda (2002).

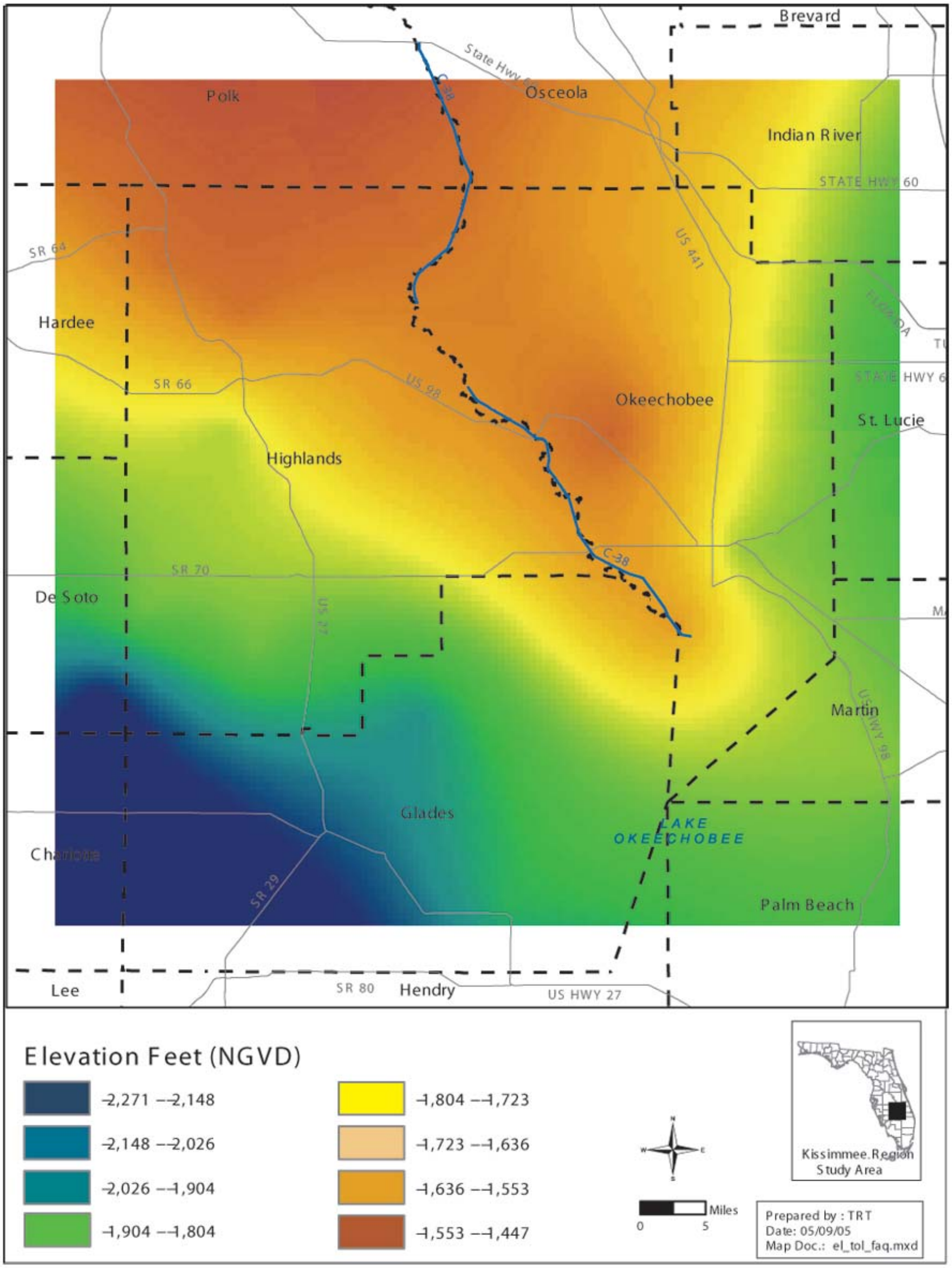

Figure 29. Elevation of Top of Lower Floridan Aquifer (Subset of Data Mapped in Reese & Richardson 2004).

Recharge and Discharge

Recharge to the Surficial Aquifer System is mainly from rainfall.

Most of recharge into the Upper Floridan Aquifer System is from the Surficial Aquifer System via the Intermediate Confining Unit. In the model area, most of this recharge occurs along Lake Wales Ridge in areas where there are sinkhole lakes, and the Intermediate Confining Unit is thin. The Confining Unit thins out and is absent in some portions of Lake Wales Ridge north of the model area (Beach and Chan 2003).

Recharge into the Middle Floridan Aquifer from the Lower Floridan Aquifer may be occurring in areas where the equivalent fresh water heads in the Middle Floridan Aquifer are lower than those in the Lower Floridan Aquifer.

In the eastern portion of the model, along the Kissimmee River and in the area surrounding northern Lake Okeechobee, artesian conditions exist in the Upper Floridan Aquifer. In **Chapter 5**, **Figure 94** shows the areas where the water levels in the Upper Floridan Aquifer exceed land elevation.

Watershed / Drainage Basins (dbasins)

Watersheds and drainage basins are often confused. Some use both terms interchangeably. A watershed is a divide separating one drainage area from another (sometimes called a drainage divide). In the United States, the area bounded by topographical divides is referred to as a watershed or drainage basin. Each large watershed can be broken into smaller sub-watersheds, which are referred to as drainage basins. The watershed is further defined as the area of land that drains water, sediment, dissolved materials and biota to a common outlet at some point along a stream channel, within the topographical divide. A drainage basin is drainage around an individual river. (Harper *et al.*[1] 2004, Gunpowder Watershed Clearinghouse Web site[2]).

The model includes portions of the following surface water watersheds (**Figure 30**): Peace River, Kissimmee River, Upper St. Johns River, Southeast Florida Coast, Caloosahatchee River, and all of Fisheating Creek and Taylor Creek. Each of these watersheds is divided into smaller drainage basins as displayed in **Figure 31**.

1 Hydrology, the Hydrologic Cycle, Watershed, Watershed Management and Watershed Water Balance http://danr.ucop.edu/uccelr/h33.htm

2 Gunpowder Watershed Clearinghouse http://www.towson.edu/gwc/

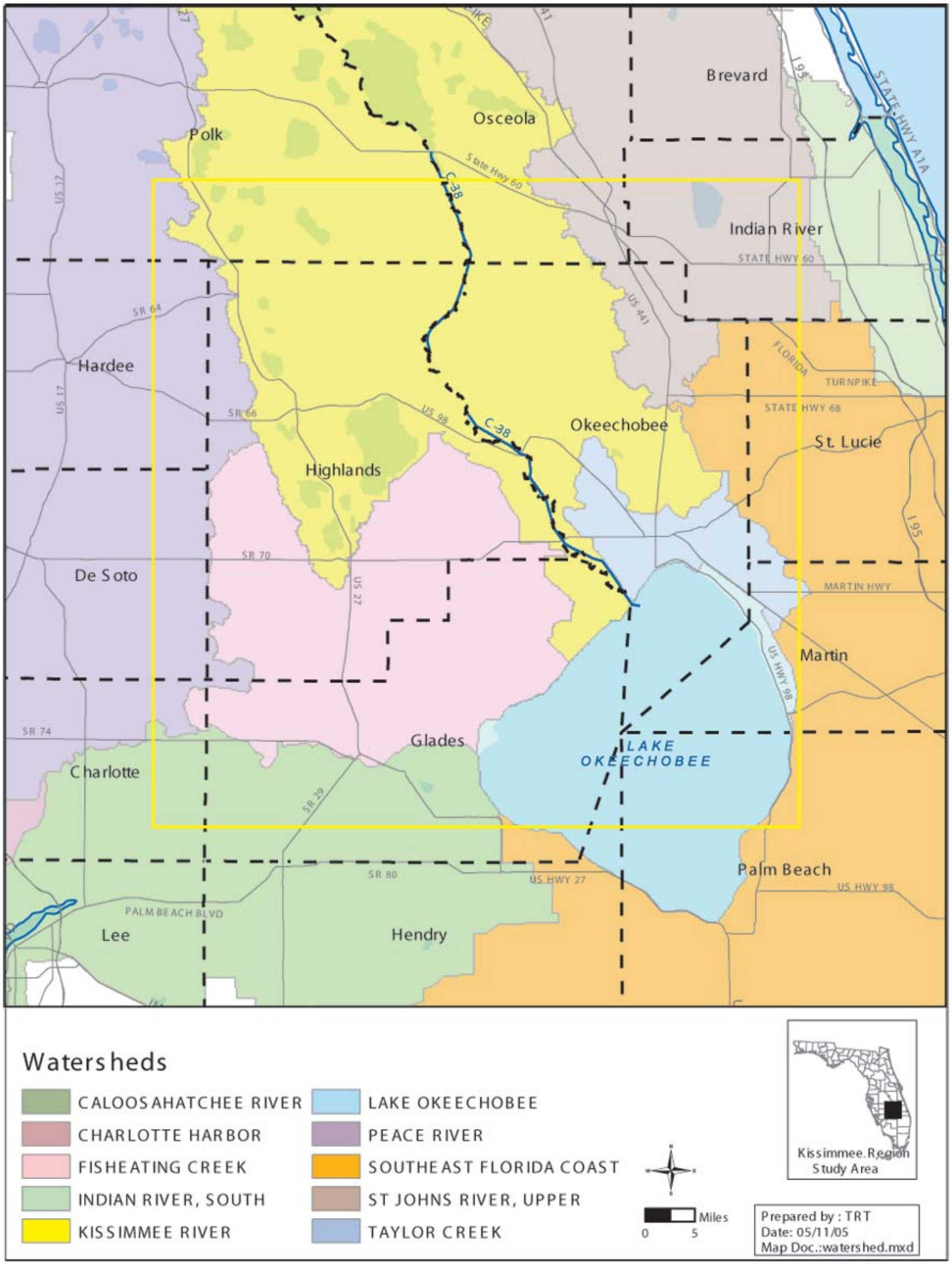

Figure 30. Watersheds.

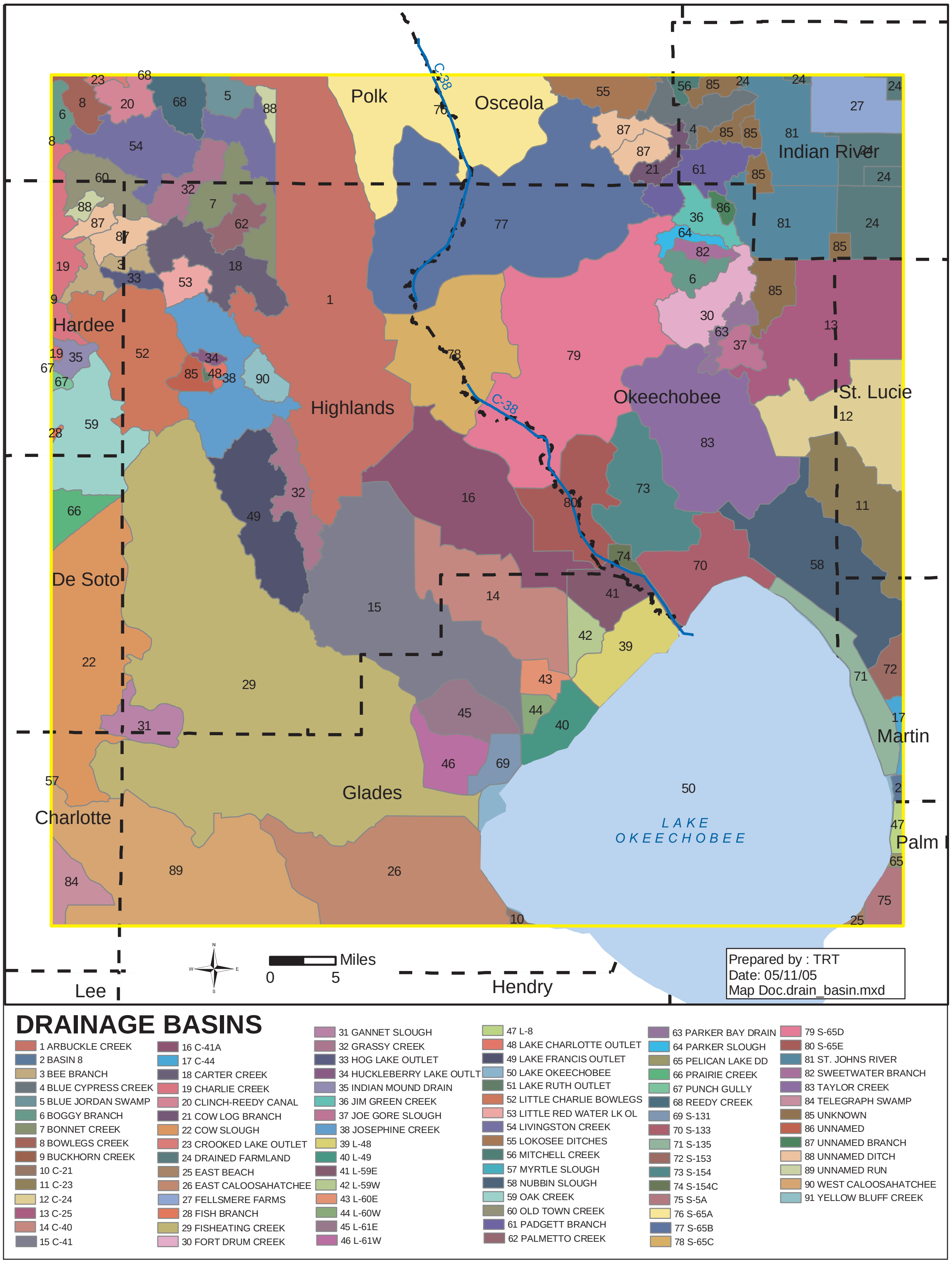

Figure 31. Drainage Basins.

Potentiometric Levels

The Floridan Aquifer System is confined or semi-confined in most portions of the model, however, recent work by Krupa *et al.* (2005) indicates that this may not be the case in the lower portion of the Lower Kissimmee River Basin. Using USGS potentiometric maps (both contours and data points were digitized) for the Upper Floridan Aquifer for September and May of 1995 (Knowles 1995) (**Figures 32** and **33**) the average 1995 potentiometric surface was calculated (**Figure 34**). The U.S. Geological Survey (USGS) did not divide the Upper Floridan Aquifer System into the Upper and Middle Floridan Aquifers, but some recently constructed nested wells along Lake Wales Ridge in Romp 28 show that the water levels in the Upper and Middle Floridan Aquifer are similar (**Figure 35**). There are no wells in the Lower Floridan Aquifer in the model area, but in east-central Florida, O'Reilly and others (2002) noted that the heads in the Lower Floridan Aquifer were 0 to 6 feet above those in the Upper Floridan Aquifer. Lukasiewicz (2001), observed water levels in the Lower Floridan Aquifer to be below the Upper Floridan Aquifer water levels, but when fresh water equivalent heads were calculated to compensate for the density differences, then the water levels in Lower Floridan Aquifer were higher than the Upper Floridan Aquifer. For the model, the starting heads for the Lower Floridan Aquifer were set to the same level as those in the Upper and Middle Floridan aquifers.

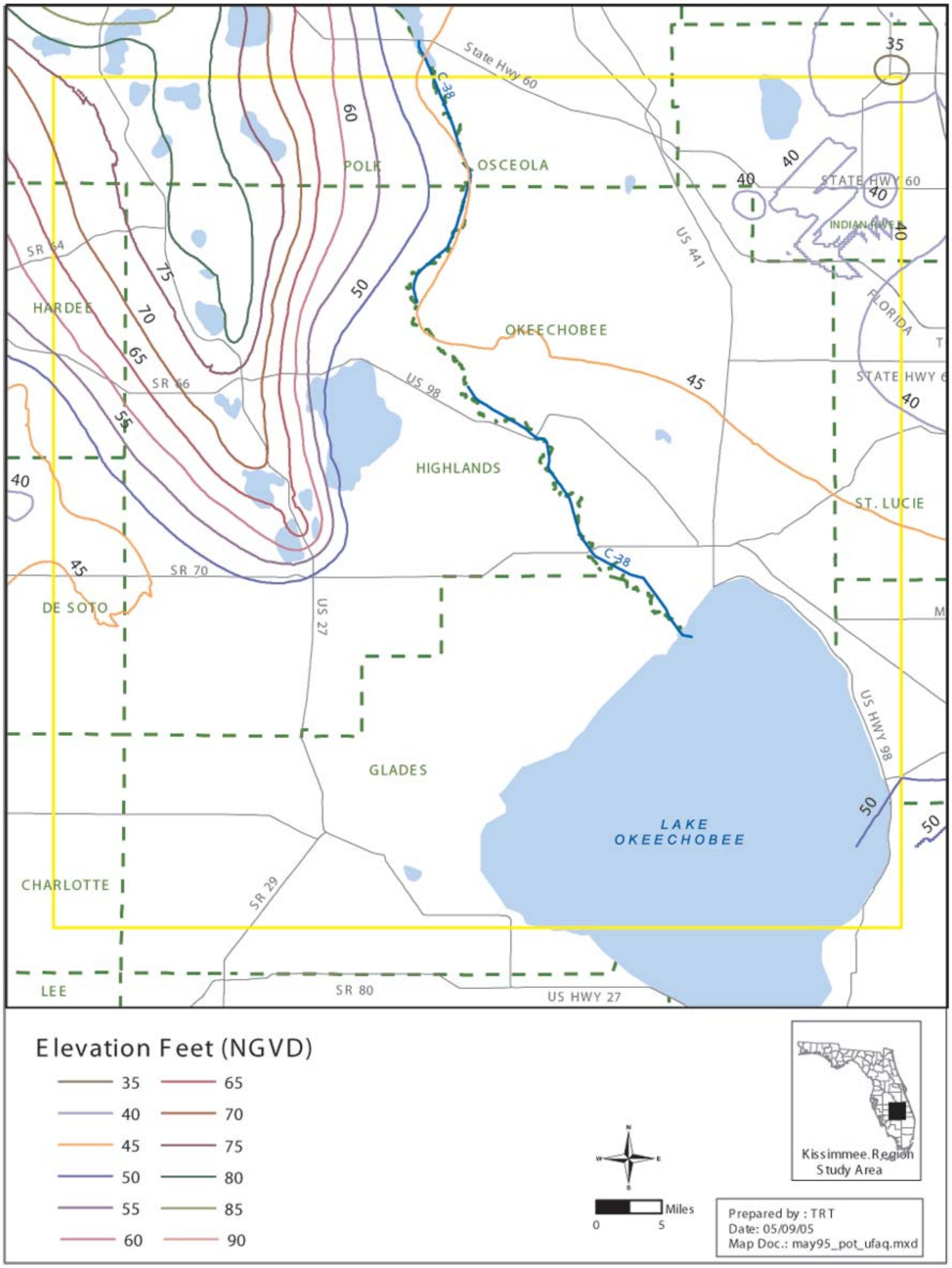

Figure 32. May 1995 Potentiometric Surface of the Upper Floridan Aquifer System (Adapted from USGS Potentiometric Maps, Knowles *et al*. 1995).

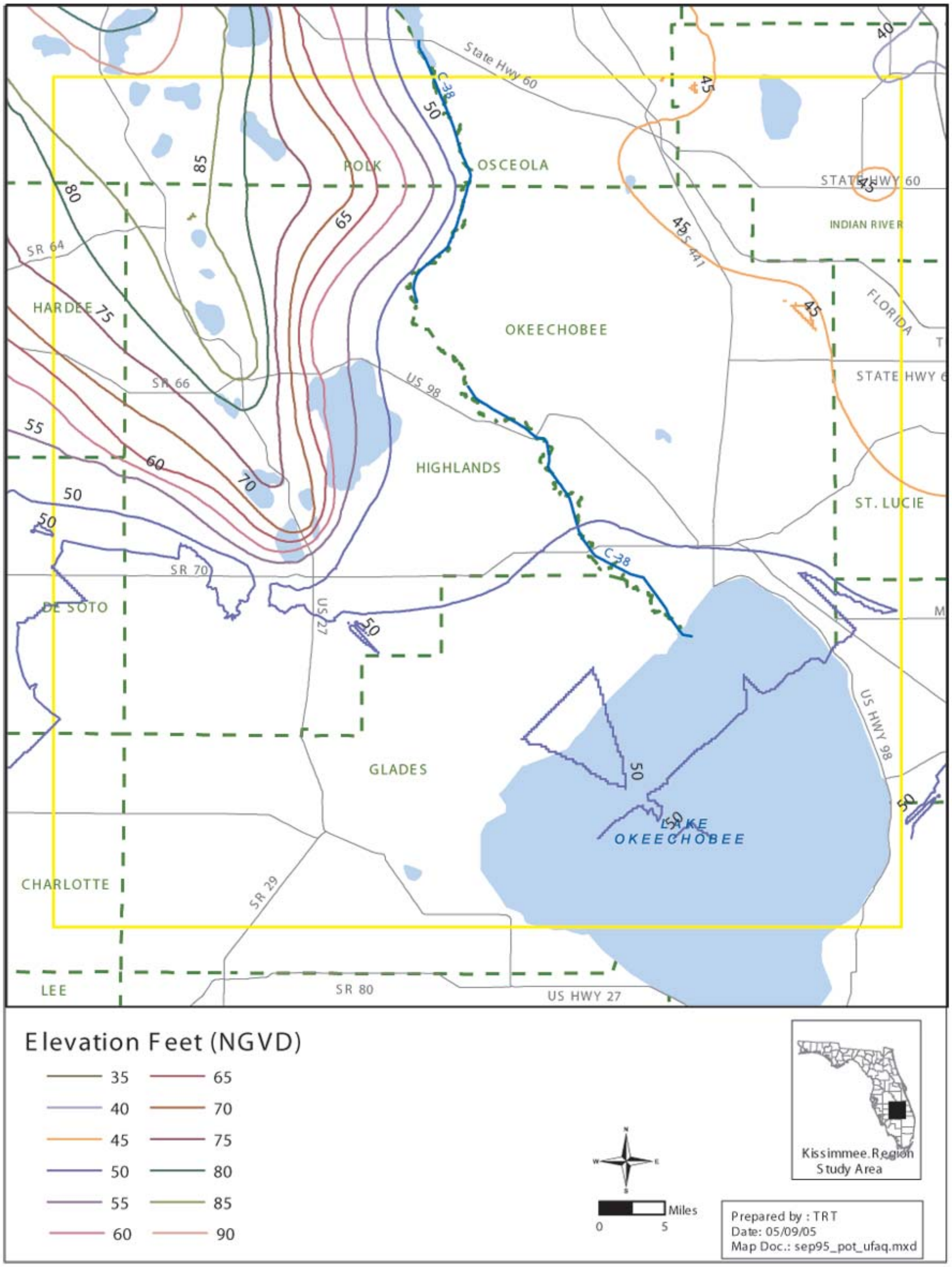

Figure 33. September 1995 Potentiometric Surface of the Upper Floridan Aquifer System (Adapted from USGS Potentiometric Maps, Knowles *et al*. 1995).

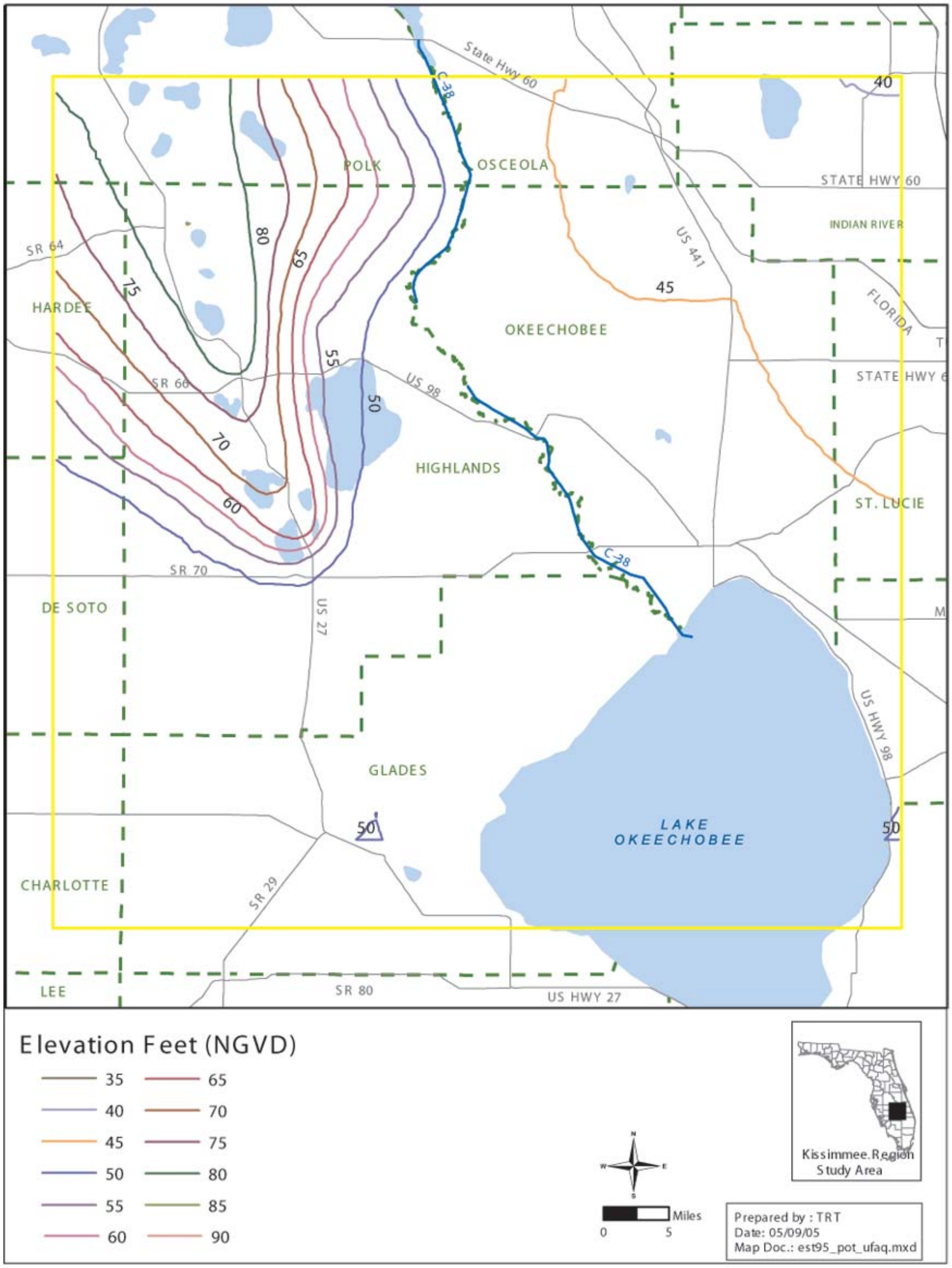

Figure 34. Estimated Average 1995 Potentiometric Surface of the Upper Floridan Aquifer System.

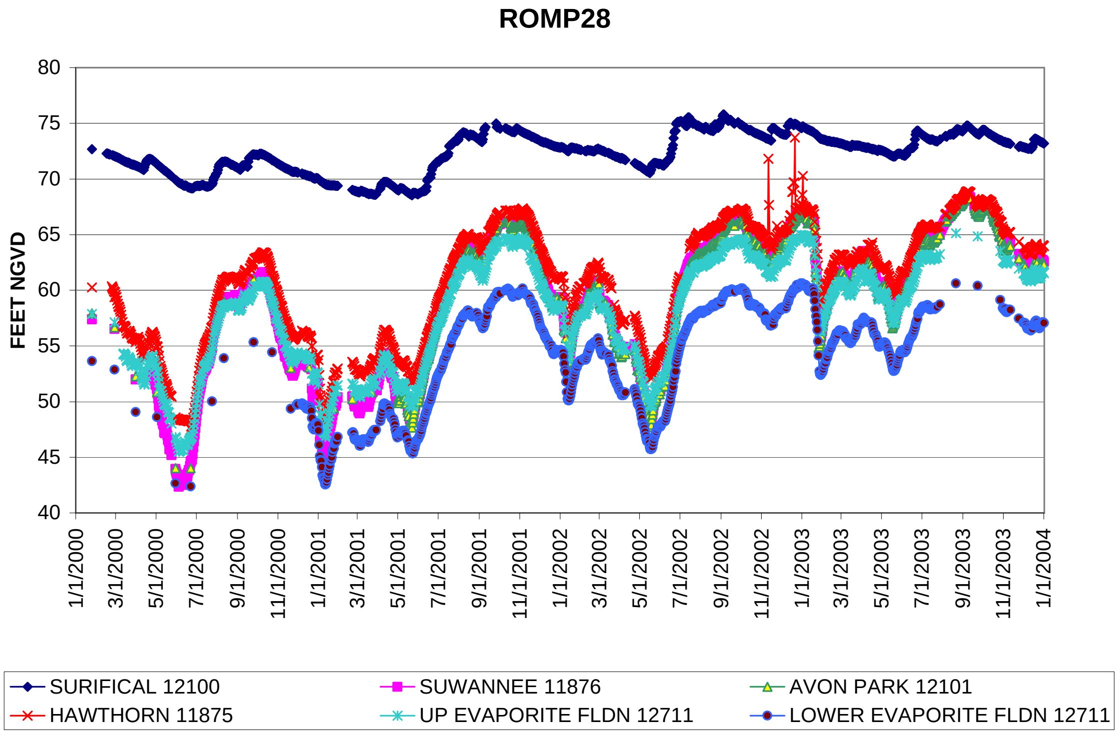

Figure 35. Compare Water Levels in Nested Well Romp 28 (Provisional Data from SWFWMD).

Historic and Projected Water Use

Agriculture is the predominant water use in the model area. Other water uses include mining and public water supply. Both surface water and groundwater are used. The Upper and Middle Floridan Aquifers are the main groundwater sources, with only 10 percent of the all the water coming from the Surficial Aquifer System. Within the Kissimmee Water Supply Plan area, the public water supply demands are projected to increase from 12 percent to 52 percent of total water consumption, while agricultural demands are projected to decrease from 43 percent to 29 percent of total water consumption. In the next 25 years, the population within the SFWMD portion of the Lower Kissimmee Groundwater Basin is projected to increase. Due to population growth urban water supply (both public water supply and domestic self-supply) will increase (SFWMD 2005). Public water supply for the Kissimmee Planning region is expected to increase by 84 percent with more residents who have private wells connecting to regional utilities and more people moving into the area. Although agricultural demands in the whole Kissimmee planning area are declining, the demands within the Lower Kissimmee Groundwater Model area have remained stable since the 2000 plan came out. Citrus and sugarcane crops have both expanded since 2000, but only citrus is expected to increase in the period through 2025 (SFWMD 2005)

Water Quality

A comprehensive study of the water quality in the region of the model domain has not been completed. Katz completed a geochemical study of the Upper Floridan Aquifer in Florida in 1992. Shaw and Trost (1984) addressed water quality of the Floridan Aquifer System in their Kissimmee Planning Area report. Data from the Surficial Aquifer were collected during 1997 to 2000 as part of a groundwater/surface water interaction study of Pools A and C in the Kissimmee River Basin (McGinnes, et al. 2003). It is recommended that a water quality sampling plan be developed and carried out prior to the next update of this model to ensure spatially distributed data are available from both the Surficial Aquifer System and the Floridan Aquifer System. This should include salinity profiles for selected Floridan Aquifer System wells with lengthy open hole or screened intervals.

The chemistry of water is classified in a number of ways. Water classification by salinity uses total dissolved solids (TDS) and is shown in **Table 2**. The TDS measurement represents all of the dissolved minerals in the water, but does not include suspended sediments, colloids or dissolved gases. Water that is considered fresh by this classification may still be unsuitable for human consumption. Primary and drinking water regulations have specifications for a number of individual parameters. A brief list of some of these parameters and their maximum allowable values are shown in **Table 3**. In this report, potable or fresh water is defined as water that meets the Florida Drinking Water Regulations. **Figure 36** presents water quality well sites by aquifer system.

Table 2. Water Classification by Salinity (Source: Kasenow 1997).

Water Classification	TDS (mg/L)
Fresh Water	< 1,000
Slightly Saline	1,000 to 3,000
Moderately Saline (Brackish)	3,000 to 10,000
Very Saline	10,000 to 35,000
Sea Water	35,000
Brine	> 35,000

Table 3. Some Parameters in the Primary and Secondary Drinking Water Regulations, Florida Administrative Code, 1982.

Parameter	Primary Standard (mg/L)	Secondary Standard (mg/L)
Sodium (Na)	160	--
Chloride (Cl)	--	250
Iron (Fe)	--	0.3
pH	--	6.5 to 8.5
Sulfate (SO4)	--	250
Total Dissolved Solids (TDS)	--	500

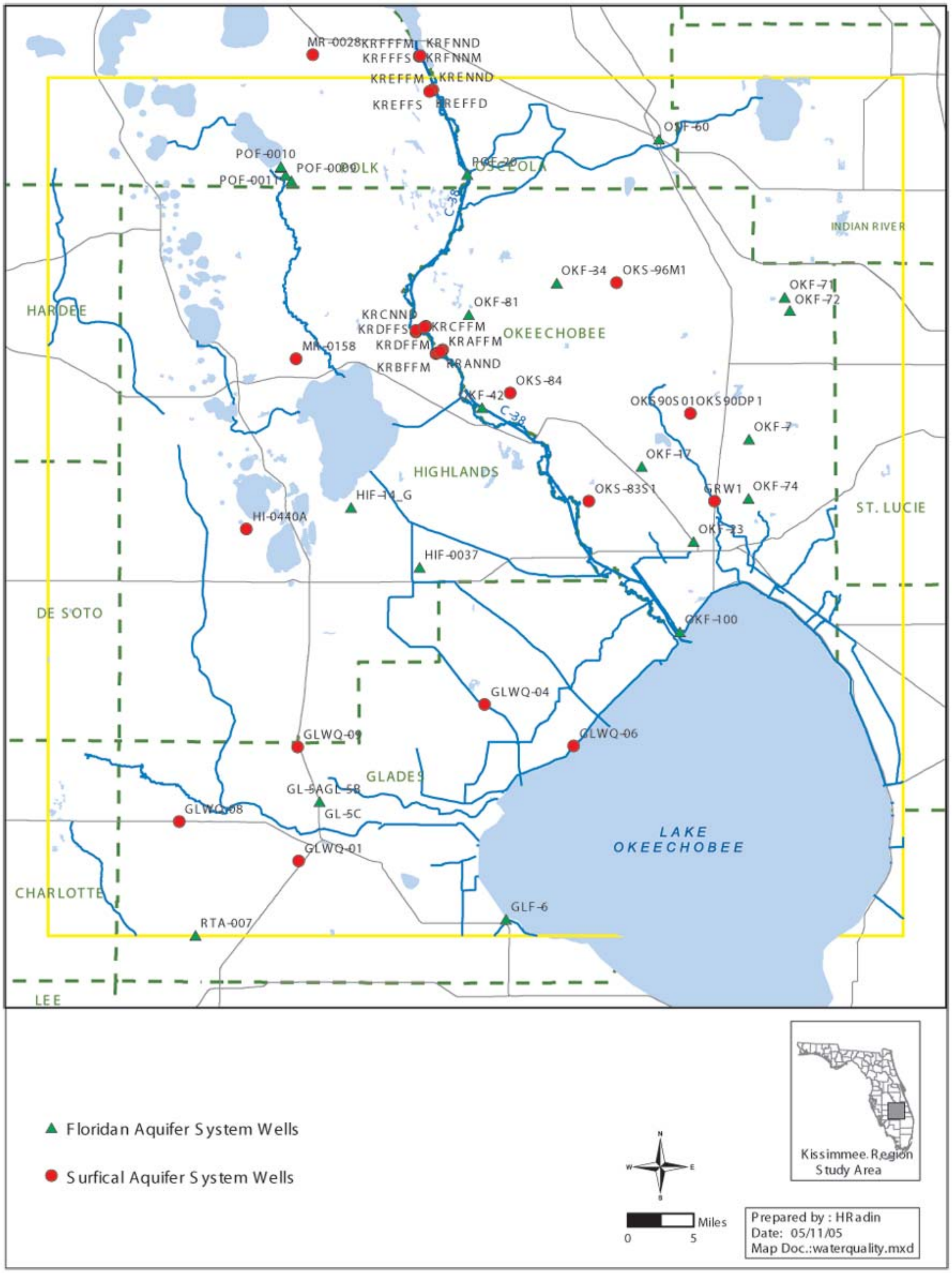

Figure 36. Water Quality Well Sites by Aquifer System.

Surficial Aquifer System

The water quality results from 41 Surficial Aquifer System wells were reviewed (see **Figure 36** and **Table 4**). The dominate ions in the water were calcium (Ca) and bicarbonate (HCO3). In fact, calcium was the primary cation in all wells reviewed, except for two wells in Glades County. Wells GLWQ-06 and GLWQ-09 both had Na-Ca-Mg water. Well GLWQ-06 is 46 feet below land surface (bls) deep and is located along the edge of Lake Okeechobee. The GLWQ-09 well is 33 feet bls and is central Glades County, just south of Highlands County.

Thirty-three of these wells have TDS levels less than 500 mg/L; the mean value for all these wells is 347 mg/L. Eight wells had TDS values greater than 500 mg/L. Five of these are shallow (< 40 feet bls) wells situated along the Kissimmee River and the remaining three are in central Glades County. The mean TDS level for all 41 Surficial Aquifer System wells was 466 mg/L.

One well exceeded the state secondary drinking water standard for chlorides; GLWQ-06 had a chloride level of 334 mg/L. Three wells, KRAFFS, KRFFFM and KRFFFS exceeded the sulfate standards with measurements of 916, 271 and 266 mg/L respectively. GLWQ-06 also exceeded the sodium standard with a measurement of 222 mg/L. The mean chloride, sulfate and sodium values for all Surficial Aquifer System wells were 35 mg/L, 51 mg/L and 33 mg/L respectively. Generally, the wells surrounding Lake Okeechobee had TDS levels greater than 1000 mg/L. Total iron measurements varied greatly from well to well and sometimes, from sampling event to sampling event. It was apparent that several wells displayed seasonal changes in the water chemistry; generally the shallow wells installed closest to the river for the Kissimmee River Groundwater/Surface Water Interaction Study showed variation of at least an order of magnitude in total iron. Sulfate levels at some of these wells, including KRDNNS1, also showed this variation.

Data from these SFWMD wells were compared to results included in the Florida Geological Survey Background Geochemistry Report (Maddox 1992) and are summarized for each county in **Tables 5, 6, 7** and **8**. Generally the SFWMD data showed more variation with lower minimums and higher maximums than the Florida Geological Survey results.

Table 4. Water Quality of the Wells in the Surficial Aquifer System.

	Type of Water	Temp (°C)	Sp Cond (uS/cm)	pH	Cl (mg/L)	SO4 (mg/L)	Alka (mg/L)	Na (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	TDS (mg/L)	Fe (mg/L)	Depth (feet bls)	Period of Record
Glades															
GLWQ-09	Na-Ca-Mg	25.7	111	5.6	12	2.4	19	9	5	0.8	2.1	90	3.4	33	05/85–11/90
GLWQ-06	Na-Ca-Mg	24.5	1,778	7.3	334	104.8	373	222	122	6.1	31.4	1,052	0.3	46	05/85–10/90
GLWQ-01	Ca-Na-H3O3	24.9	146	5.8	12	7.5	52	12	16	0.8	2.6	100	0.5	54	05/85–10/89
GLWQ-04	Ca-Na-H3O3	25.3	1,264	6.8	133	13.2	430	114	135	3.2	23.8	791	0.3	75	05/85–10/90
GLWQ-08	Ca-Na-Mg	25.4	1,555	6.8	113	171.8	434	125	125	3.1	51.7	977	0.3	85	05/85–10/90
Highlands															
MR-0158	Na-Cl-HCO3	25.3	74.5	5.5	5	6.6	7	9	6	0.1	0.2	62	2.4	10	07/85–02/93
HI-0440A	Na-Cl-SO4	25.8	163	5.9	10	4.9	4	3	1	1.3	0.4	97	37.4	23	07/85–07/90
KRDFFS	Ca-HCO3	23.8	487	6.3	33	3.9	207	23	72	1.6	7.5	418	8.2	25	09/97–01/01
KRDNNS1	Ca-HCO3	24.2	696	7.0	22	25.4	310	23	121	2.9	8.6	451	1.2	25	09/97–01/01
KRBFFS	Ca-HCO3	23.7	586	6.8	22	0.7	262	21	93	1.7	6.4	374	0.5	26	09/97–01/01
KRBNNS	Ca-HCO3	24.1	632	7.2	17	2.5	307	21	103	1.8	8.2	380	0.4	30	09/97–01/01
KRBFFM	Ca-HCO3	24.0	596	7.2	15	0.5	321	19	113	2.2	7.9	397	0.2	46	09/97–01/01
KRBNNM	Ca-HCO3	24.3	624	7.3	16	0.6	322	20	111	2.3	7.9	398	0.2	49	09/97–01/01
KRDFFM	Ca-HCO3	23.9	565	7.3	19	1.0	309	26	103	2.7	5.0	375	0.6	51	09/97–01/01
KRDNNM1	Ca-HCO3	24.3	604	7.5	19	0.5	299	25	100	2.9	6.2	370	0.3	52	09/97–01/01
KRDNND1	Ca-HCO3	24.0	602	7.3	17	0.3	296	24	115	3.3	6.0	375	0.1	83	09/97–01/01
KRBNND	Ca-HCO3	24.0	617	7.2	17	0.4	306	19	108	2.7	7.7	388	0.4	98	09/97–01/01
Okeechobee															
GRW1	Ca-HCO3	23.1	320	5.5	13	5.6	106	12	38	2.3	3.1	285	3.2	17	11/01–09/03
KRCNNS	Ca-HCO3	24.2	757	7.0	31	40.7	305	30	118	1.6	11.5	459	2.0	20	09/97–01/01
OKS-83S1	Na-Cl--HCO3	24.6	95	5.4	11	1.7	10	17	3	0.1	0.7	103	8.1	20	04/93–10/93
OKS90S01	Ca-Na-HCO3-Cl	23.4	186	5.8	17	1	55	10	19	2.4	2.5	118	4.9	21	12/92–10/93
KRAFFS	Ca-SO4-HCO3	24.1	2,231	6.5	21	916	436	29	482	2.4	31.7	1,696	18.0	24	10/97–01/01
KRANNS	Ca-HCO3-SO4	24.9	1,284	6.6	11	227	460	9	262	3.4	10.6	767	0.4	24	10/97–01/01
KRCFFS	Ca-HCO3	23.9	753	7.2	30	20.8	345	31	122	1.8	9.8	491	0.9	25	09/97–01/01
KRAFFM	Ca-Na-HCO3	24.3	605	7.1	34	2.3	273	31	91	1.9	6.4	352	1.3	40	10/97–01/01
KRCFFM	Ca-Na-HCO3	23.8	618	7.2	26	0.5	283	31	94	1.7	8.0	382	0.7	42	09/97–01/01
KRCNNM	Ca-Na-HCO3	24.1	572	7.4	32	0.7	244	41	74	1.7	6.9	345	0.1	43	09/97–01/01
KRANNM	Ca-Na-HCO3-Cl	25.0	641	7.3	50	1.4	245	33	90	2.0	6.7	382	0.3	49	10/97–01/01
OKS-96M1	Ca-Na-HCO3-Cl	24.2	756	6.9	73	1.7	259	46	106	0.5	14.0	480	0.4	51	04/93–10/93
KRCNND	Ca-Na-HCO3	23.9	560	7.4	26	1.5	247	32	77	2.3	7.2	339	0.0	86	09/97–01/01
OKS90DP1	Ca-HCO3	22.9	514	7.0	10	1.0	180	14	57	7.4	4.2	327	0.2	93	04/93–10/93
KRANND	Ca-Na-HCO3	24.4	612	7.4	43	5.2	238	34	83	2.2	7.8	356	0.2	96	10/97–01/01
OKS-84	Ca-Na-HCO3-Cl	25.3	840	7.4	64	9.8	287	68	103	1.8	8.6	482	0.4	178	04/93–10/93

Table 4. Water Quality of the Wells in the Surficial Aquifer System (Continued).

	Type of Water	Temp (°C)	Sp Cond (uS/cm)	pH	Cl (mg/L)	SO4 (mg/L)	Alka (mg/L)	Na (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	TDS (mg/L)	Fe (mg/L)	Depth (feet bls)	Period of Record
Polk															
MR-0028	Na-Ca-SO4-Cl	26.1	122	4.2	10	16.6	7	18	4	1.5	2	5	2.4	8	07/85–05/88
KREFFS	Ca-HCO3	24.6	584	6.5	5	1.4	298	5	109	1.5	6.3	380	0.1	21	10/97–01/01
KRFNNS	Ca-HCO3	24.3	701	6.7	6	27.5	337	10	125	2.0	14.9	464	0.0	21	10/97–01/01
KRENNS	Ca-HCO3	23.2	656	6.8	6	11.7	326	5	133	1.7	7.8	443	0.0	21	10/97–01/01
KRFFFS	Ca-HC03-SO4	23.0	1,552	6.5	34	266	554	29	293	0.9	34.5	961	26.0	21	10/97–01/01
KRFNNM	Ca-Mg-HCO3	24.2	1,023	6.6	21	29.7	523	26	160	2.1	30.1	743	0.1	34	10/97–01/01
KRFFFM	Ca-HC03-SO4	22.8	1,548	6.5	37	271	539	32	284	1.0	35.6	1,041	21.3	36	10/97–01/01
KRENNM1	Ca-HCO3	23.2	681	6.8	8	4.6	339	16	128	1.9	8.2	446	0.0	37	10/97–01/01
KREFFM	Ca-HCO3	24.5	621	6.7	11	0.7	290	24	105	1.9	5.3	340	0.9	41	10/97–01/01
KRENND	Ca-Na-HCO3	23.2	493	7.3	19	0.5	227	29	73	1.5	4.9	313	0.0	116	10/97–01/01
KRFNND	Ca-Na-HCO3	24.1	670	7.1	35	0.6	280	47	87	1.9	5.5	421	0.5	116	10/97–01/01
KREFFD	Ca-Na-HCO3	23.6	490	7.3	11	1.9	235	27	71	1.4	4.5	309	0.2	120	10/97–01/01

Glades County

Data were obtained from five Surficial Aquifer System wells in Glades County. Two wells had Na-Ca-Mg water and three had Ca-Na-HCO3 or Ca-Na-Mg water. The TDS levels in three wells was 791 mg/L or higher. The two wells with TDS < 500 mg/L had pH levels of 5.6 and 5.8. All wells had at least one total iron measurement that exceeded 0.3 mg/L and GLWQ-01 and GLWQ-09 had mean levels of 0.54 mg/L and 3.4 mg/L respectively.

Table 5. Comparison of Water Quality Parameters in the Surficial Aquifer System in Glades County

Parameter	SFWMD Data	Data from FGS Report
pH	5.6 to 7.3	6 to 7
Calcium (mg/L)	5 to 135	~ 50 to 100
Sodium (mg/L)	9 to 222	10 to 50
Total Iron (mg/L)	0.02 to 11	Non-detectable to 3.25
Chlorides (mg/L)	12 to 334	10 to 100
Sulfate (mg/L)	2 to 172	Generally < 10

Highlands County

Data from ten wells and two surface water sites along the Kissimmee River were reviewed. All wells had Ca-HCO3 water and TDS levels < 500 mg/L. All other drinking water standards were met, except well KRDFFS had a pH of 6.3. All wells had chloride levels less than 45 mg/L. The mean total iron for the Highlands county wells was 0.89 mg/L. Three wells, KRBFFM, KRDNND1 and KRDNNM1 had all total iron measurements less than 0.3 mg/L, while the mean iron at KRDFFS was 8.2 mg/L. Well KRDNNS1 displayed great variation with total iron ranging from 0.028 to 9.05 mg/L; this variation was also seen in the sulfate values. Some sulfate levels were below detection limits (BDL).

Table 6. Comparison of Water Quality Parameters in the Surficial Aquifer System in Highlands County

Parameter	SFWMD Data	Data from FGS Report
pH	6.6 to 7.5	6 to 6.5
Calcium (mg/L)	72 to 121	~ 50 to 100
Sodium (mg/L)	19 to 26	10 to 20
Total Iron (mg/L)	0.02 to 11	2.8 to 9.7
Chlorides (mg/L)	15 to 33	10 to 100
Sulfate (mg/L)	BDL to 25	Generally < 10

Okeechobee County

The most common water type seen in the 15 Surficial Aquifer System wells in Okeechobee County was Ca-Na-HCO3. All wells deeper than 40 feet bls, except for OKS90DP1, had Ca-Na-HCO3 or Ca-Na-HCO3-Cl water. All wells, except for two met primary and secondary drinking water standards. KRANNS had a TDS of 767 mg/L and a sulfate level of 227 mg/L. KRAFFS had a TDS level of 1696 mg/L and a sulfate level of 916 mg/L. The sulfate level at all other wells in the county was <41 mg/L. Total iron was measured at all wells, except GRW1 and OKS90S01; total dissolved iron was measured at these two sites. Wells KRCNND and KRCNNM had all total iron measurements lower than 0.3 mg/L. Wells KRANND and KRANNM had at least one measurement greater than 0.3 mg/L, but a mean total iron less than 0.3 mg/L. The remaining 11 wells had mean values greater than 0.3 mg/L. KRAFFS had a mean total iron of 18 mg/L.

Table 7. Comparison of Water Quality Parameters in the Surficial Aquifer System in Okeechobee County.

Parameter	SFWMD Data	Data from FGS Report
pH	5.4 to 7.4	6.5 to 7
Calcium (mg/L)	20 to 482	~ 50 to 100
Sodium (mg/L)	9 to 68	10 to 50
Total Iron (mg/L)	0.02 to 27	Less than 1
Chlorides (mg/L)	10 to 73	Generally ~10
Sulfate (mg/L)	1 to 916	Generally < 10

Polk County

Only a portion of Polk County is included in this model. However, water quality results from areas outside the model were included because parts of this county are recharge areas for the Floridan Aquifer System. Data were obtained from 11 Surficial Aquifer System wells in Polk County; all are located along the Kissimmee River. Seven of these wells are less than 41 feet bls. The most common water type of these seven wells is Ca-HCO3. Two of these have Ca-HCO3-SO4 water and one has Ca-Mg-HCO3. Three wells are deeper than 115 feet bls. These wells all had Ca-Na-HCO3 water. The wells in Polk County showed the greatest variation in total iron. The mean at KRFNNS was 0.017 mg/L and 26.0 at KRFFFS. Four wells, KREFFM, KREFFS, KRFFFS and KRFNND, had mean total iron greater than 0.3 mg/L. The total iron measurements at the other seven Polk County Surficial Aquifer System wells were all lower than 0.3 mg/L.

Table 8. Comparison of Water Quality Parameters in the Surficial Aquifer System in Polk County.

Parameter	SFWMD Data	Data from FGS Report
pH	4.2 to 7.3	6.0 to 6.5
Calcium (mg/L)	4 to 293	~ 10 to 100
Sodium (mg/L)	5 to 47	10 to 20
Total Iron (mg/L)		0.84 to 2.09
Chlorides (mg/L)	5 to 37	Generally ~10
Sulfate (mg/L)	BDL to 30	Generally ~10

Floridan Aquifer System

It is more difficult to analyze water from the Floridan Aquifer System because of the complexity of the aquifer and because of common methods used to construct Floridan wells. The aquifer has multiple production zones whose thicknesses vary spatially across the model domain. Many, if not most, Floridan wells are constructed with long open holes or screened intervals, which are open to more than one zone. As such, unless packers are used for water quality sampling, it is difficult to determine what zone the water sample is from. Water chemistry also varies based on the well site; wells located in the Floridan Aquifer System recharge areas generally have lower TDS and major ions levels than wells in the Floridan Aquifer System discharge regions.

For this model, water quality results were obtained from 25 Floridan wells located in the model domain. From four of these wells only TDS and chlorides were sampled. Major ions, TDS and field parameters were obtained at the remaining 21 wells (**Table 10**).

Shaw and Trost (1984) found the dominant water type in the recharge areas was calcium-bicarbonate water. They found sodium chloride waters in discharge areas, which can be indicative of connate water with higher chlorides and total dissolved solids. Analysis of SFWMD data found the five wells in the Floridan Aquifer System recharge areas of Polk County to have calcium-bicarbonate water. The primary water types in the remaining wells were sodium-chloride, sodium-bicarbonate and sodium-sulfate. OKF-81, located in the northern portion of Okeechobee County, also had calcium-bicarbonate water.

Katz (1992) indicates that chlorides in the Upper Floridan Aquifer are generally less than 50 mg/L because of the rainfall recharge. Five of the six SFWMD Upper Floridan wells had chloride measurements greater than 110 mg/L including OKF-74 with a mean chloride value of 1639 mg/L. Well OSF-60 had a mean chloride of 27 mg/L. In the Kissimmee area, deeper wells have higher concentration of sulfate because of contact with gypsum and connate seawater (Katz 1992). Three Floridan Aquifer System wells had sulfate levels in excess of 1,000 mg/L. One (OKF-74) is in the Upper Floridan Aquifer and the other two are in the Lower Floridan Aquifer.

The Southwest Florida Water Management District (SWFWMD) has installed a series of shallow and deep monitor and observation wells (ROMP 28) in Highlands County, south of Sebring and at ROMP 14, also in Highlands County, south of Lake Istokpoga. As a part of the installation, SWFWMD collected TDS, chlorides and SO4 measurements to depth. At ROMP 14, the values were low (<200 mg/L) until about 1,750 feet bls when all levels increased. At ROMP 28, TDS and SO4 values changes significantly from about 1,400 feet bls to the bottom of the hole about 2,100 feet bls. However, the chlorides varied minimally. These profiles are shown in **Figures 37** and **38**.

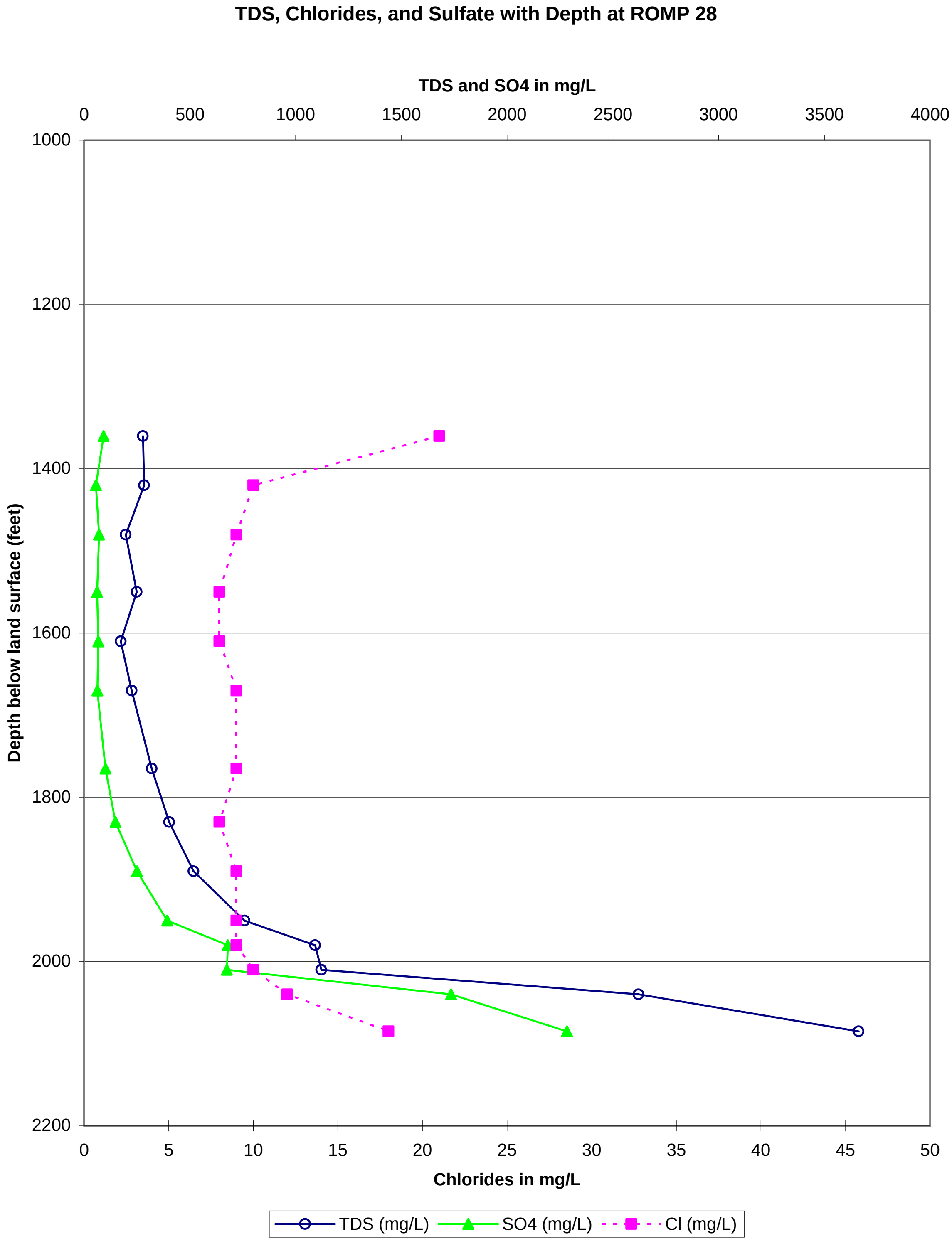

Figure 37. Water Quality Profile of SWFWMD ROMP Well 28.

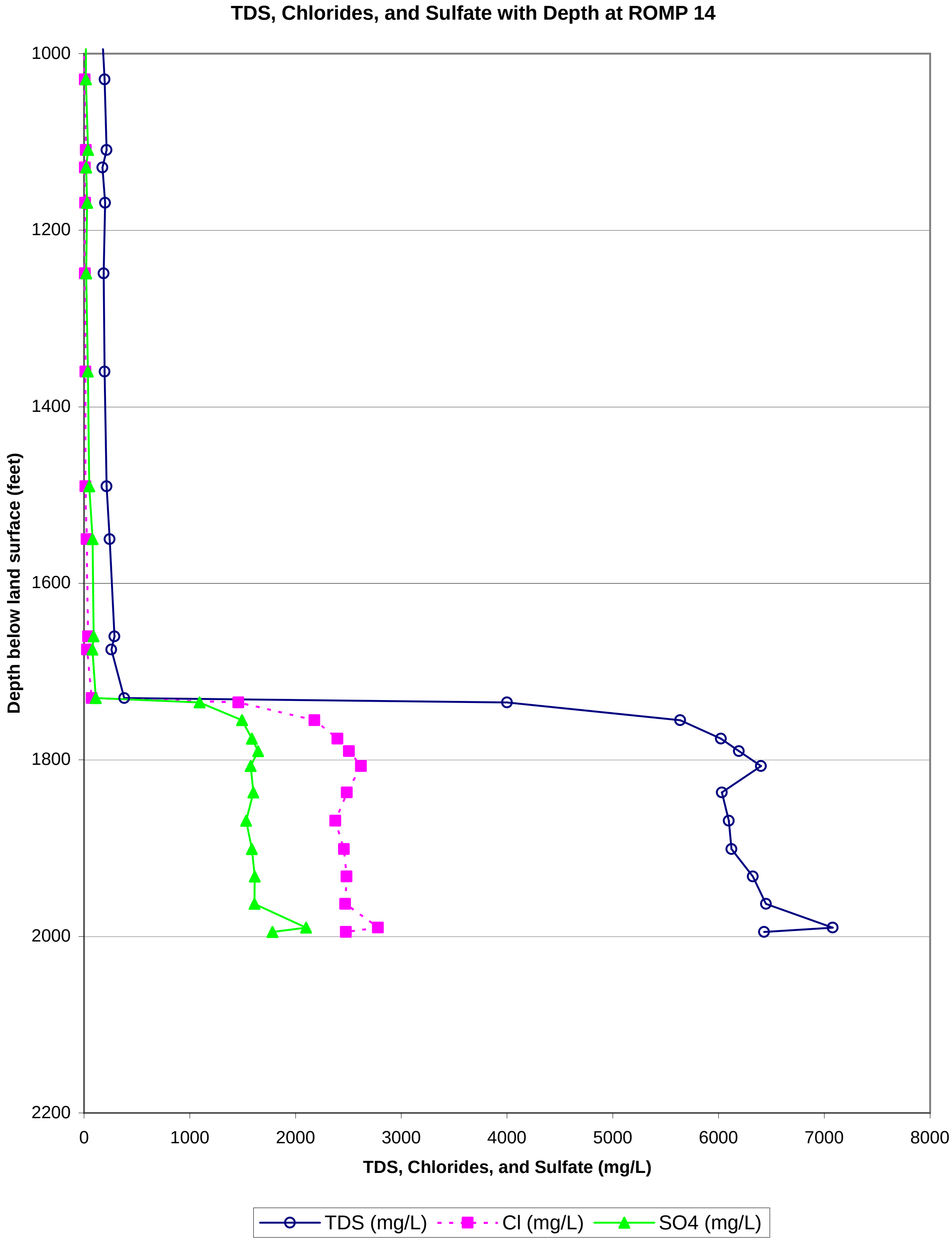

Figure 38. Water Quality Profile of SWFWMD ROMP Well 14.

In general, data from the 25 SFWMD Floridan Aquifer System wells (**Table 10**) did not appear to show patterns based on zone or depth. Generally, the wells in the area around Lake Okeechobee had TDS levels in excess of 1,000 mg/L and chlorides greater than 250 mg/L.

Piper diagrams were prepared for the Surficial Aquifer System wells in Glades, Highlands and Okeechobee counties and Floridan Aquifer System wells in Glades and Okeechobee counties, and are include in **Figures 39** through **43**. There was insufficient Floridan Aquifer System data in Highlands County to facilitate a Piper diagram. Expected patterns, based on which production zone is open to the well, were not identified. This could be because a number of the samples are from wells with a long open hole or screened interval and thus, the water is a mixture from several production zones.

Data from the SFWMD wells were compared to results from the Florida Geological Survey Background Geochemistry report (Maddox 1992) and are summarized in **Table 9**. Generally the SFWMD data showed more variation with lower minimums and higher maximums than the Florida Geological Survey (FGS) results.

Table 9. Comparison of Water Quality Parameters in the Floridan Aquifer System in Glades, Highlands and Okeechobee Counties.

Parameter	SFWMD Data	Data from FGS Report
pH	6.9 to 8.1	7 to 7.5
Calcium (mg/L)	15 to 550	~ 25 to 100
Sodium (mg/L)		
Glades	15 to 1,500	50 to 100
Highlands/Okeechobee	15 to 1,000	50 to 600
Chlorides (mg/L)		
Glades	25 to 2,900	100 to 500
Highlands	30 to 120	50 to 100
Okeechobee	15 to 4,600	50 to 500
Sulfate (mg/L)		
Glades/Okeechobee	1 to 1,900	100 to 250
Highlands	< 10	10 to 100

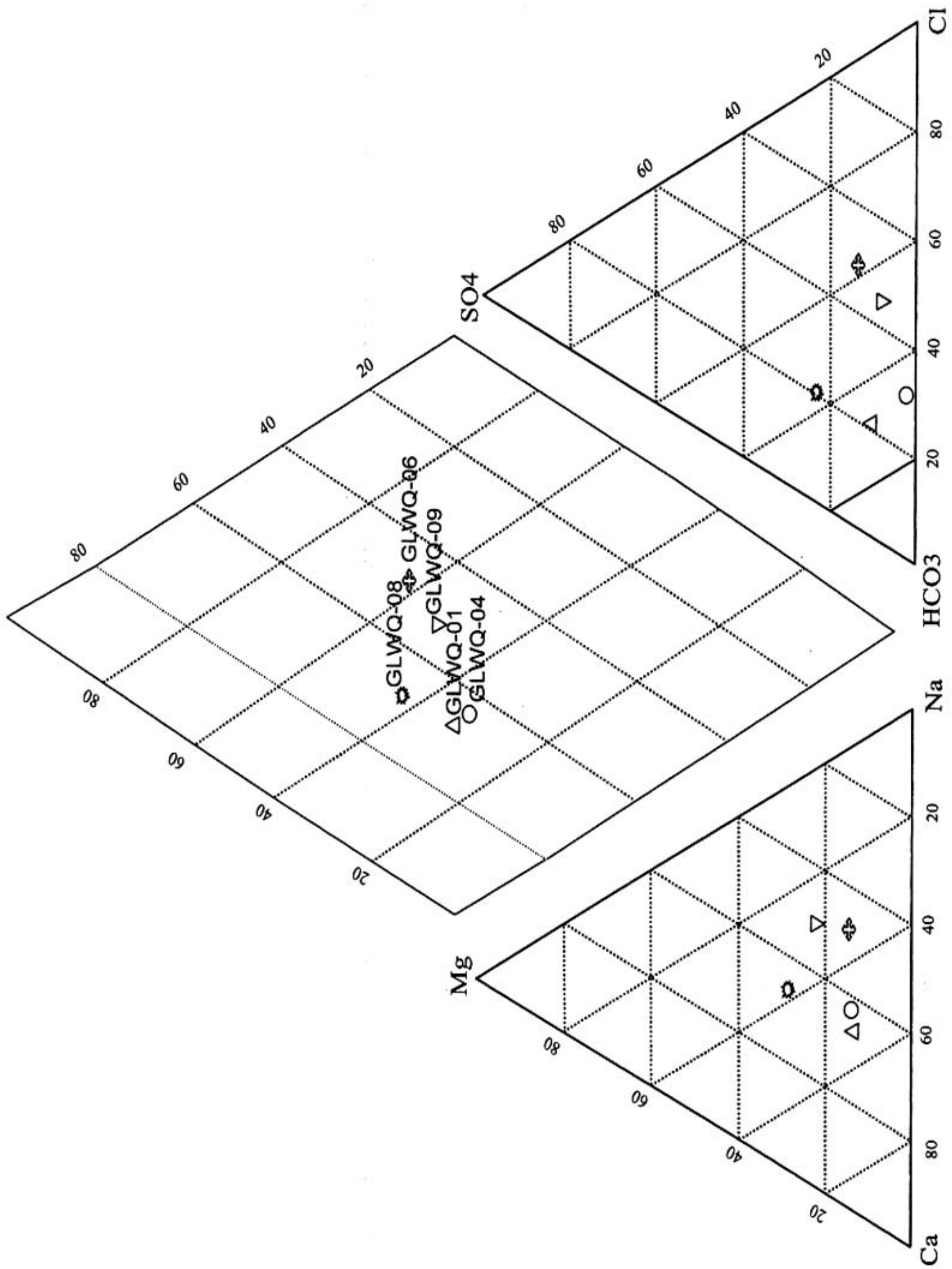

Figure 39. Piper Diagram of the Surficial Aquifer Wells in Glades County.

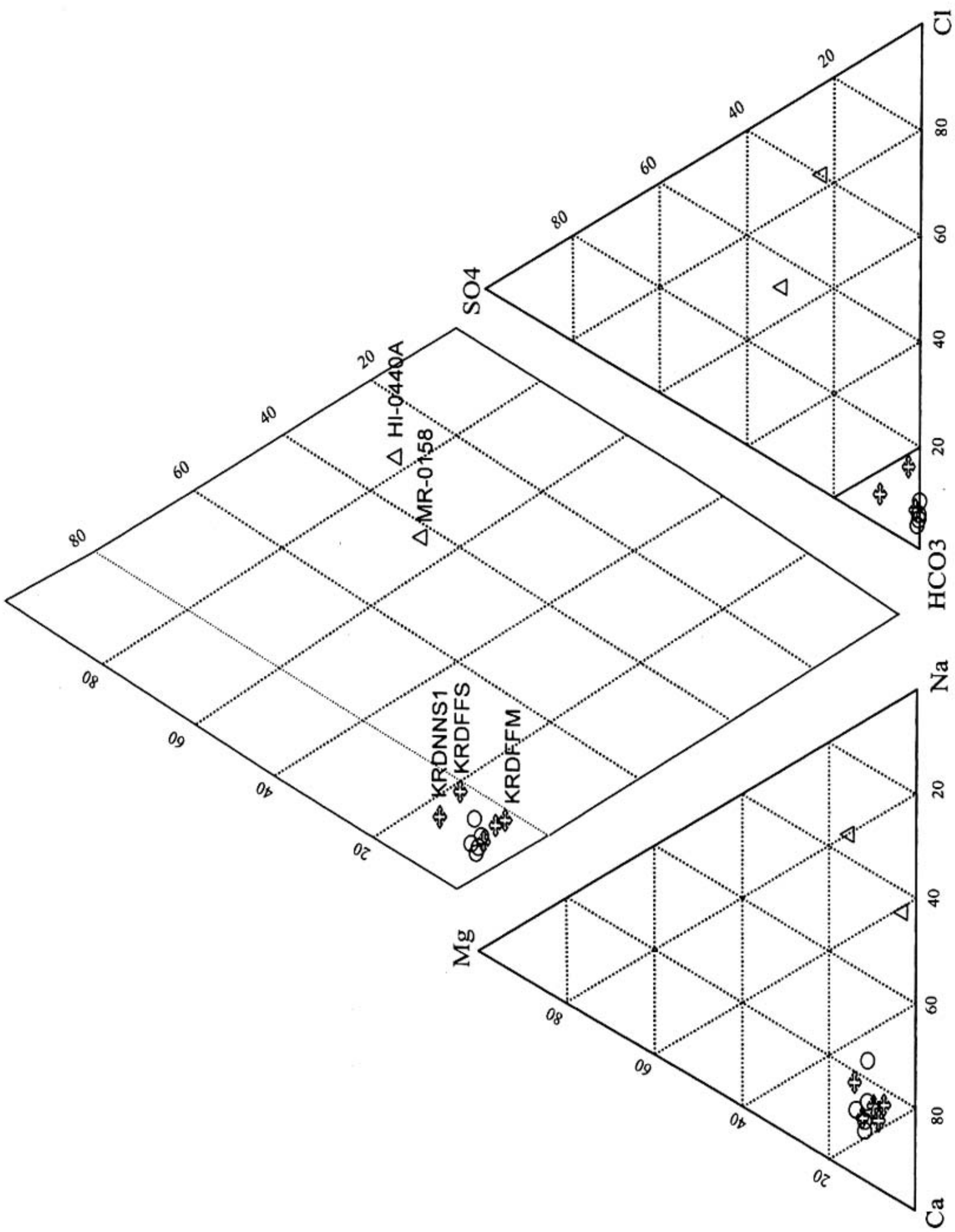

Figure 40. Piper Diagram of the Surficial Aquifer Wells in Highlands County.

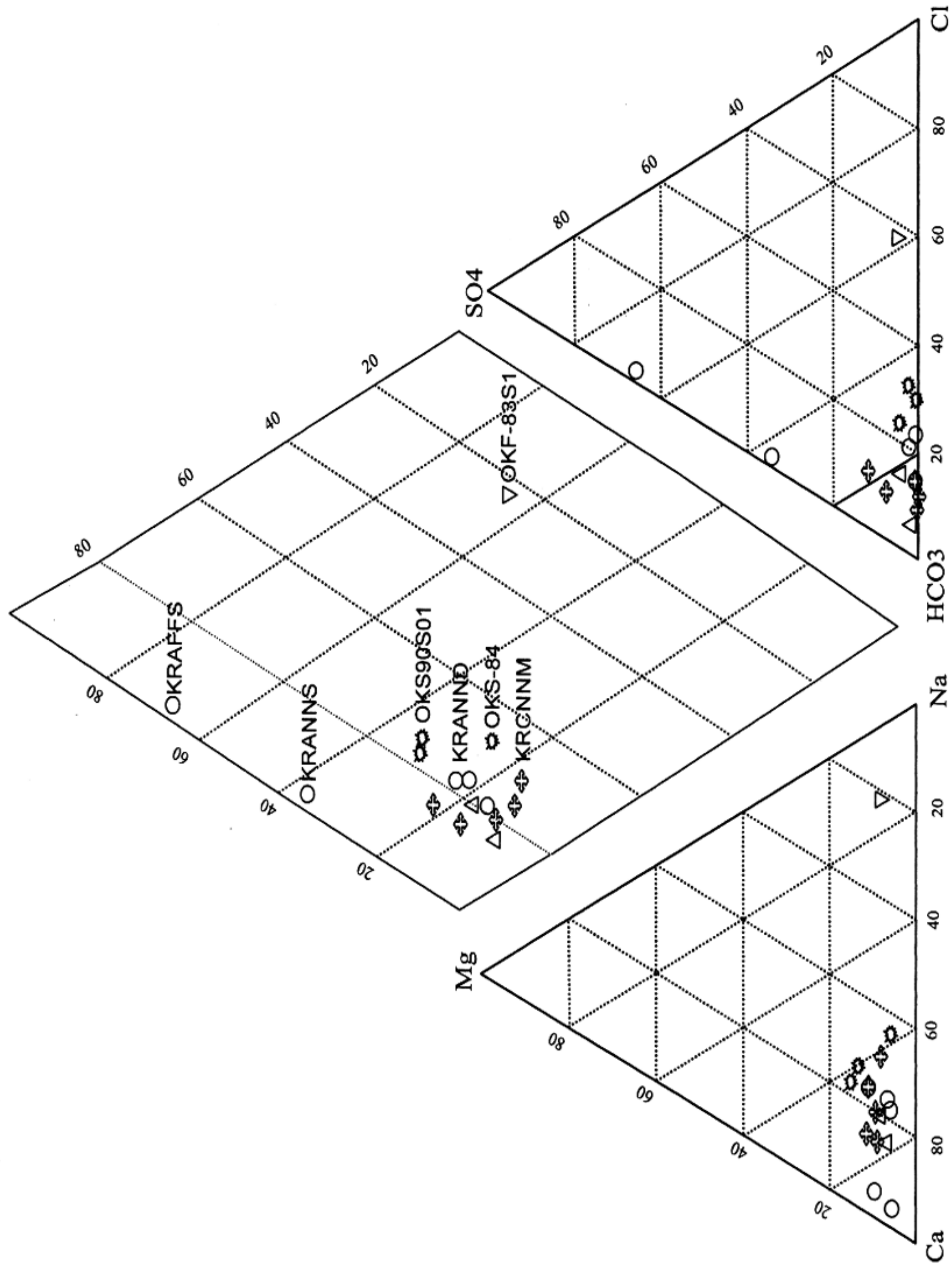

Figure 41. Piper Diagram of the Surficial Aquifer Wells in Okeechobee County.

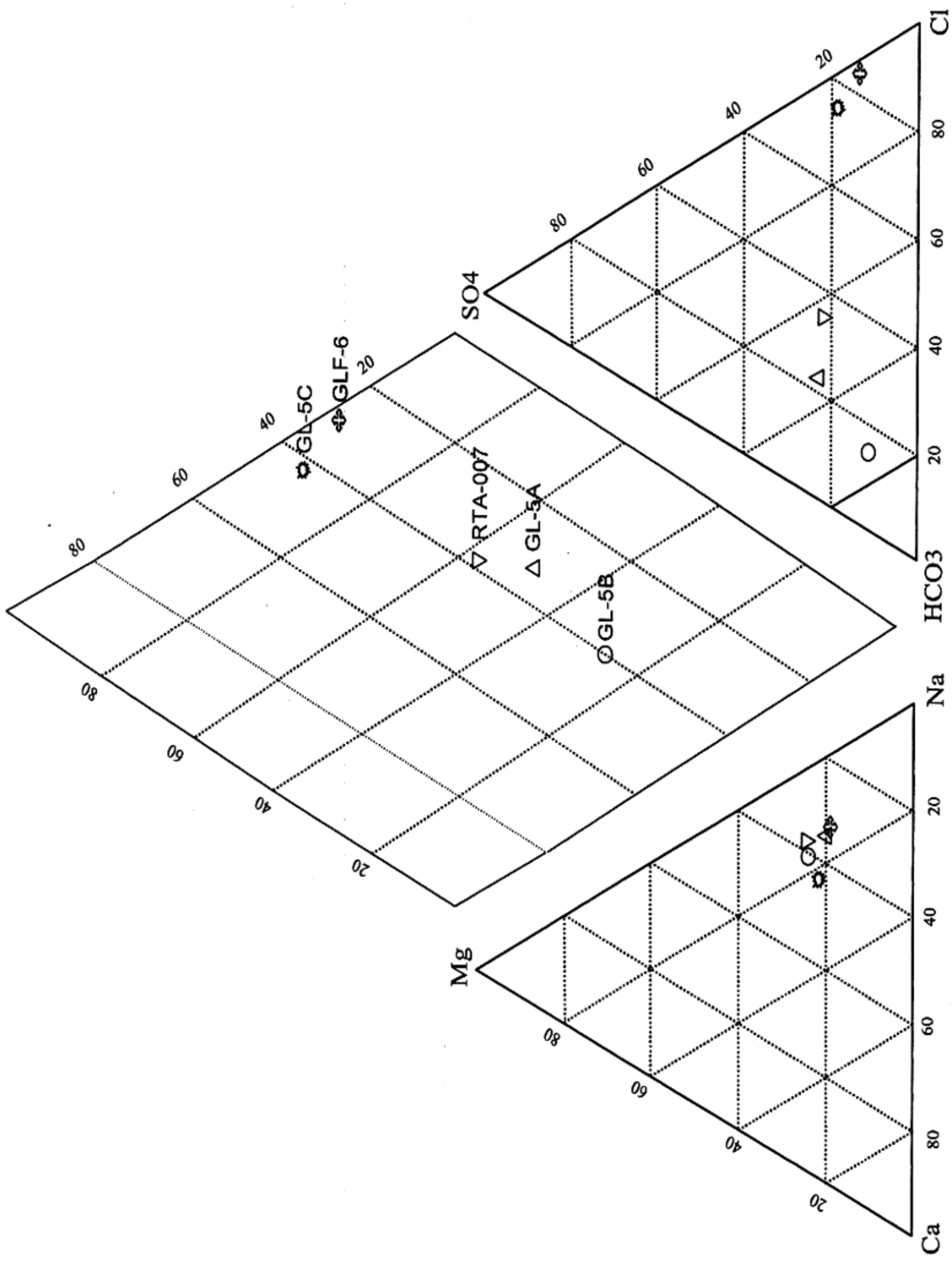

Figure 42. Piper Diagram of the Floridan Aquifer Wells in Glades County.

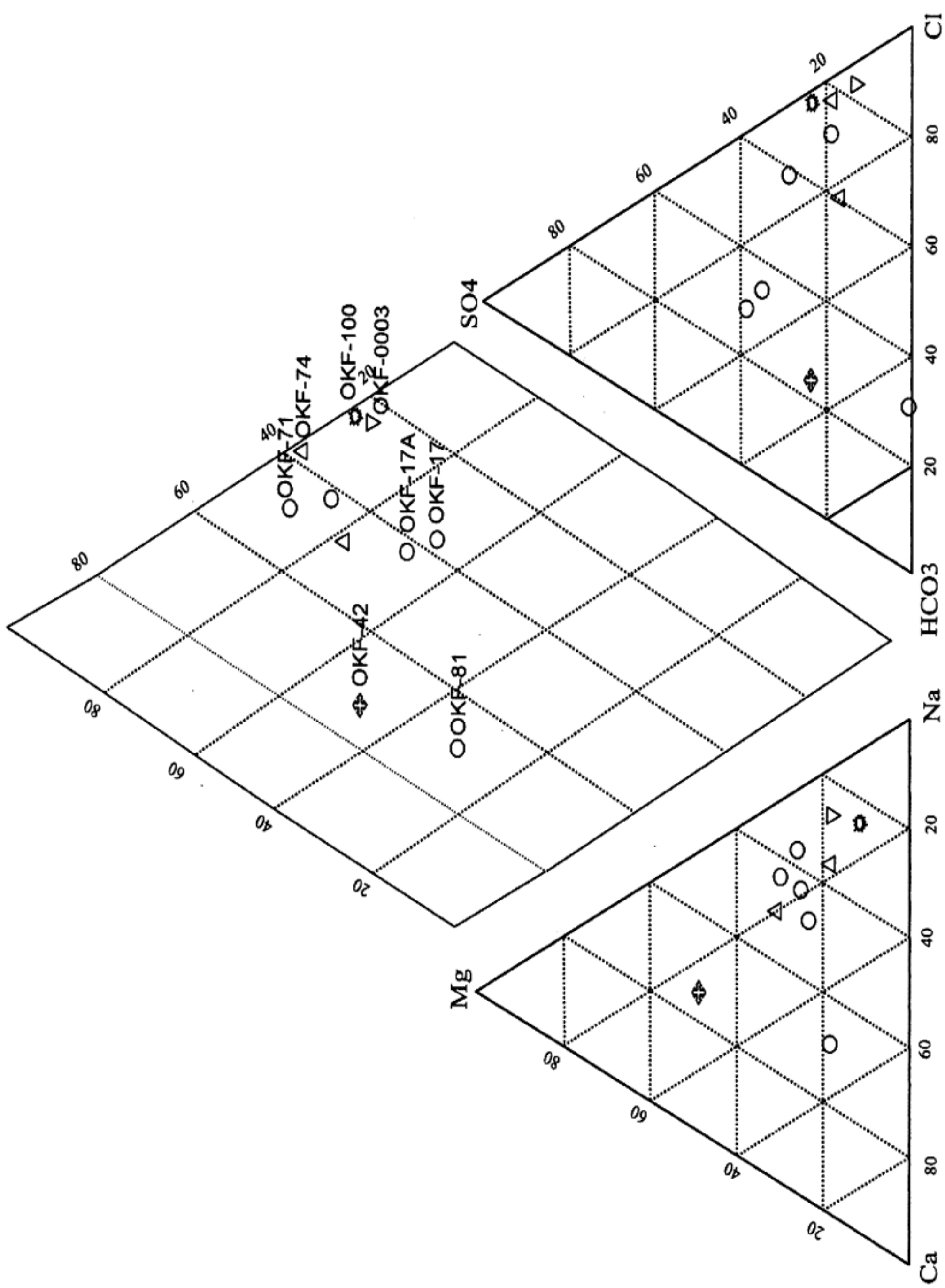

Figure 43. Piper Diagram of the Floridan Aquifer Wells in Okeechobee County.

Table 10. Water Quality of the Wells in the Floridan Aquifer System.

	Type of Water	Temp (°C)	Sp Cond (uS/cm)	pH	Cl (mg/L)	SO4 (mg/L)	Alka (mg/L)	Na (mg/L)	Ca (mg/L)	K (mg/L)	Mg (mg/L)	TDS (mg/L)	Zone/ Depth	Period of Record
Glades														
GL-5C	Na-Mg-Ca-Cl	27.8	2,113	7.7	540	186	74	251	84	5.8	51.3	1,263	uf	09/99
RTA-007	Na-Mg-HCO3-Cl	26.4	936	7.6	110	88	185	120	26	9.1	24.2	485	uf	05/85–11/90
GL-5A	Na-HCO3-Cl-SO4	26.0	525	8.0	45	60	138	84	15	3.9	12.8	310	ic	09/99
GL-5B	Na-Mg-HCO3-Cl	25.4	469	7.8	25	27	177	68	17	4.3	13.9	285	mc1	09/99
GLF-6	Na-Cl	30.5	10,295	7.5	2,871	609	80	1,459	247	41.0	203.0	5,907	lf	10/01–11/01
Highlands														
HIF-0037					118							315	uf	
HIF-14_G					30							174	mc2	
Okeechobee														
OKF-72	Na-Mg-Cl	27.0	1,593	7.4	283	115.5	145	161	56	8.1	51.4	802	uf	10/89–11/93
OKF-74	Na-Cl	27.7	6,590	6.9	1,639	543.8	100	974	253	25.6	150.4	3,929	uf	10/89–12/93
OKF-0003	Na-Cl	24.6	3,380	7.6	1,103	241.1	75	632	63	25.0	83.0	2,344	ic	
OKF-17	Na-Mg-SO4-HCO3	26.6	912	8.1	92	164.6	142	125	18	10.1	28.1	527	mc1	04/93–10/93
OKF-23	Na-Mg-Cl-SO4	25.9	1,656	7.4	323	205.3	99	211	61	8.4	44.9	953	mc1	04/93–11/93
OKF-7	Ca-HCO3	25.0	528	7.2	15	1.0	149	15	86	1.1	5.4	248	mc1	04/93–12/93
OKF-71	Na-Ca-Mg-Cl	26.5	2,790	7.1	677	242.8	135	277	110	7.8	63.8	1,622	mc1	10/89–11/93
OKF-81	Ca-Na-HCO3	24.5	815	6.9	82	2.4	262	50	69	3.7	15.7	410	mc1	09/87–02/05
OKF-42	Mg-Na-Ca-HCO3	25.7	710	7.6	60	86.6	194	42	34	5.4	40.1	417	mf	09/87–2/05
OKF-34					104							491	mf	
OKF-100	Na-Cl-SO4	29.2	15,611	7.5	4,557	1,896.5	89	3,203	541	68.8	268.1	10,549	lf	12/01–5/04
OSF-60					27							419	?–590	
Polk														
POF-20	Ca-Mg-HCO3	25.7	605		88	1.0	194	39	67	2.7	15.9	359	260–1000	07/04
POF-0012	Ca-Mg-HCO3	24.9	157	7.5	4	13.2	64	2	17	0.6	6.3	93	0–432	09/78–09/79
POF-0011	Ca-Mg-HCO3	23.7	158	7.5	5	10.0	65	0	17	0.6	6.7	101	0–930	09/78–09/79
POF-0010	Ca-Mg-HCO3	25.3	157	7.7	3	10.7	64	3	17	0.8	6.3	101	0–540	09/78–09/79
POF-0009	Ca-Na-Mg-HCO3	24.4	152	7.5	6	12.8	63	4	17	0.6	5.9	101	0–1045	09/78–09/79